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MIUS COMMUNITY CONCEPTUAL DESIGN STUDY

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MODULAR INTEGRATED UTILITY SYSTEMS
improving community utility services by supplying electricity, heating, cooling, and water/ processing liquid and solid wastes/ conserving energy and natural resources/ minimizing environmental impact

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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16. Abstract

This design study was performed to determine the feasibility, practicality, and applicability of the modular integrated utility systems (MIUS) concept to a satellite new-community development with a population of approximately 100 000. Two MIUS design options — 29-MIUS-unit (option I) and 8-MIUS-unit (option II) facilities — were considered. Each resulted in considerable resource savings when compared to a conventional utility system. The results of economic analyses indicated that the total cash outlay and operations and maintenance costs for these two options were considerably less than for a conventional system. Computer analyses performed in support of this study provided corroborative data for the study group. An environmental impact assessment was performed to determine whether the MIUS meets or will meet necessary environmental standards. The MIUS can provide improved efficiency in the conservation of natural resources while not adversely affecting the physical environment.

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MIUS COMMUNITY CONCEPTUAL

DESIGN STUDY

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HUD-MIUS Program

The Department of Housing and Urban Development (HUD) is conducting the Modular Integrated Utility System (MIUS) Program devoted to development and demonstration of the technical, economic, and institutional advantages of integrating the systems for providing all or several of the utility services for a community. The utility services include electric power, heating and cooling, potable water, liquid waste treatment, and solid waste management. The objective of the MIUS concept is to provide the desired utility services consistent with reduced use of critical natural resources, protection of the environment, and minimized cost. The program goal is to foster, by effective development and demonstration, early implementation of the integrated utility system concept by the organization, private or public, selected by a given community to provide its utilities.

Under HUD direction, several agencies are participating in the HUD-MIUS Program, including the Atomic Energy Commission, the Department of Defense, the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Bureau of Standards (NBS). The National Academy of Engineering is providing an independent assessment of the program.

This publication is one of a series developed under the HUD-MIUS Program and is intended to further a particular aspect of the program goals.

Coordinated Technical Review

Drafts of technical documents are reviewed by the agencies participating in the HUD-MIUS Program. Comments are assembled by the NBS Team, HUD-MIUS Project, into a Coordinated Technical Review. The draft of this publication received such a review and all comments were resolved.

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MIUS COMMUNITY CONCEPTUAL

DESIGN STUDY

By Ben E. Fulbright
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SUMMARY

The modular integrated utility systems (MIUS) Community Conceptual Design Study was performed to determine the applicability of the MIUS concept to a new satellite community of 100 000 persons. Two MIUS design options were considered -- one containing 8-MIUS-unit facilities and one containing 29-MIUS-unit facilities. A conceptual design description and a system specification for an MIUS-supplied community have resulted from this study. Parametric evaluations of size and type of facilities to be included in the community have been made. Energy conservation devices were considered, cost analyses were performed, and the costs of the MIUS-supplied community and the conventionally supplied community were compared. The analysis indicated that considerable resource savings could be obtained by using the MIUS instead of the conventional methods of providing utility services. This study indicated that the MIUS concept is capable of supporting a community of 100 000 persons while conserving natural resources without adversely affecting the physical environment.

INTRODUCTION

The purpose of the modular integrated utility systems (MIUS) Community Conceptual Design Study was to investigate, through a conceptual design, the application of the MIUS concept to a new satellite community and to determine the technical and economic feasibility of an MIUS in such a community. An objective was to develop an MIUS conceptual design description and system specification for such a community. Additionally, the consumables usage, environmental impact, and costs of an MIUS were compared with those of a conventional system, and various optimization analyses were performed on the MIUS.

Originally, the plan for conducting MIUS conceptual design studies included several "point" designs and a design for a "combination of facilities." The point designs -- designs for a particular building type -- that were chosen included an office building, a shopping center, a hospital, a school, garden apartments, and high-rise apartments.

During the pursuit of the point design studies, the Integrated Utilities Systems Board of the National Academy of Engineering requested, on January 5, 1973, a conceptual design study consisting of (1) 500 to 2000 dwelling units and associated services including schools and shops, (2) an urban renewal project, (3) a suburban planned development, and (4) a new satellite community.

The new satellite community was chosen for the combination-of-facilities study because it incorporated the most probable construction situations. Modularity and developmental phasing were to be considered, and, although the development of the community was to be phased over approximately 20 years, all MIUS designs were to be based on 1975 technology. A community locale with an average climatic area was selected.

It should be noted that this is a design study for a very hypothetical community development. Inherent in such design cases is a degree of inapplicability to the design for a real community. This lack of applicability is caused by a number of factors such as specific topography of the locale, causing a deterrent to layout of the community and utility distribution in such an optimal fashion as that proposed in this report.

All types of energy and resource-conserving devices were considered. When those devices were not unique to the MIUS, they were carefully distinguished. Common transmission and distribution systems combining various utility services were considered, and the MIUS was designed with sufficient standardization to facilitate operation and maintenance activities.

In the cost analyses performed, payback was not considered; only total owning and operating costs were considered. Twenty-year projections were made when analyzing costs of all items. Distortions due to taxes, governmental subsidies, and existing utility rate structures were not considered. The effects of mass production of the MIUS were not considered in the cost analyses. When cost comparisons between conventional utilities and the MIUS were made, the assumption was that the conventional system must add capacity for servicing the satellite community.

Figure 1 is a schematic of the design study logic. The output resulted in a comparison of the MIUS and conventional systems and in systems specifications for the community MIUS.

As an aid to the reader, where necessary the original units of measure have been converted to the equivalent value in the Systeme International d'Unites (SI). The SI units are written first, and the original units are written parenthetically thereafter. For appendix E, the JSC Director waived the use of SI units, because, in his judgment, the use of SI units impaired the usefulness of the material and resulted in excessive cost.

COMMUNITY MODEL

To study the feasibility of an integrated utility system on the community scale, a model was generated that described the characteristic physical components and representative buildings of satellite new towns. (The largest number of new towns are satellite new towns rather than new towns-in-town or freestanding new towns.) Once described, these components could be arranged in a land use scheme consistent with existing planning principles.

Designing a proper model necessitated defining the typical American satellite new-town components and describing them in a form that facilitated the various MIUS-related analyses. Common components of new towns have been identified by a survey of various American new towns. Proper understanding of the MIUS application in such a new community required that all experimental, advanced, or controversial community planning concepts be avoided. Social aspects were not investigated because they were considered to be outside the scope of the task. Site-specific features (natural conditions such as landform, hydrology, geology, vegetation, and climate) were not included because a site for the MIUS has not been determined. Because transportation is an important part of community planning, standard forms of transportation have been included in structuring the plan.

Figure 2 displays the logic used for selecting the study model. Fourteen American new-town designs were surveyed to determine the state of the art of new-town design and to identify common components of new towns. The basic elements, or building blocks, in the town designs examined included neighborhoods, village centers, villages, and a central business district (CBD).

Based on the survey and a comparison of the new towns with the study criteria, Columbia, Maryland, an existing planned new town consistent with the state of the art was selected as the basic model. This model provides a "real" background for components based on population and economy. Parts of the selected model, unique to that new town, were identified and expressed as a distortion from the "typical" new town. Components were then simplified and arranged in a land use diagram that was used for utility analysis. Appendix A contains supportive data for the new-town model.

MIUS CONCEPTUAL DESIGN

The MIUS designed for the new community is required to provide the following six basic services.

1. Electrical power at 120/208-volt three-phase ac power to all occupied space

2. Potable water that meets the 1962 U.S. Public Health Service standards for drinking water

3. Domestic hot water, of potable quality, heated to 339 K (150° F)

4. Heating, ventilation, and air-conditioning (HVAC) with the space-heating capacity and space-cooling capacity to meet the heating and cooling loads in the Washington, D.C., environment

5. Wastewater treatment consistent with the requirements of recycling for nonpotable use and/or disposal to the external environment

6. Solid waste disposal by transportation and incineration consistent with applicable Environmental Protection Agency (EPA) standards

Optimization Criteria, Reliability, and Code Approvals

The optimization approach used in the MIUS Community Conceptual Design Study was the minimization of discounted cash flow; that is, whenever the design strategy offers more than one alternative, the alternative having the lowest present cost is selected.

Cash flow is the movement of cash into and out of a given enterprise. Discounted cash flow is an analytical

tool that differs from a cash-flow analysis in that it takes into consideration the time at which the money flows into and out of the enterprise. The future dollar is "converted" to its present value in the cost analysis of an item.

The reliability requirement determines the redundancy provided in the design of the system and influences the selection of equipment and the decisions concerning interconnection of systems. For the MIUS community conceptual design, the reliability provided is comparable to that of conventional systems.

Organizations and agencies have produced codes, guidelines, design criteria, and regulations relevant to the conceptual design of an MIUS. These codes and standards affected the design selection. Where possible, they were complied with, but they were not a constraint on the study. However, where there is a major deviation from the accepted practice or codes, such deviation is justified or explained. A partial list of the sources of codes, guidelines, and regulations is as follows.

Air Movement and Conditioning Association

American Association of State Highway Officials

American Gas Association

American Society of Civil Engineers

American Society of Heating, Refrigeration, and Air-Conditioning Engineers

American Society of Mechanical Engineers

American Society for Testing Materials

American Standards Association

American Water Works Association

Association of Edison Illuminating Companies

Compressed Air and Gas Institute

Insulated Power Cable Engineers' Association

National Board of Fire Underwriters

National Electrical Manufacturers' Association

National Elevator Manufacturing Industry, Incorporated

National Fire Protection Association

Plumbing and Drainage Institute

Steel Boiler Institute

Underwriters' Laboratories

Illuminating Engineering Society

Military Standards

Military Specifications

Bureau of Yards and Docks

National Bureau of Standards

Federal Construction Council

Environmental Protection Agency

U.S. Public Health Service

Electrical Power Subsystem Criteria

Fuel oil for the generation of electrical power is the basic energy source for an MIUS. A 24-hour-supply fuel storage tank is provided at each MIUS site within the design community. Replenishment of the fuel is from offsite (extracommunity) storage through an underground pipeline.

Electrical power generated by the MIUS is distributed underground to the various user elements. Power is generated at 60 hertz, three-phase only. The single-family detached dwellings are all-electric, because electricity is the only energy source supplied to these dwellings. All systems operate independently of, but compatibly with, the extracommunity power system.

Minimum-heat-rate engines are used in the power generation. Heat-recovery equipment is compatible with the HVAC system.

A design goal for all subsystems was to obtain maximum commonality of subsystem components without decreasing efficiency and without violating the optimization criterion.

Heating, Ventilation, and Air-Conditioning Subsystem Criteria

Only absorption machines and compression machines were considered for cooling purposes. The subsystem is designed to maximize the utilization of waste heat for both summer cooling and winter heating. If necessary, supplemental boilers are used to meet the winter space-heating peaks. Compressive cooling is used if supplemental cooling capacity is required, but it must be economically justified.

A circulating hot- and chilled-water system is used for the high-density regions of the community -- the high-density area of the neighborhoods, the village center, and the CBD. The design was optimized so that, where possible, heat is rejected directly to the environment so that water can be conserved.

Solid-Waste Subsystem Criteria

The solid waste of the community is disposed of by incineration. In this manner, energy, in the form of heat, is recovered from the wastes. The heat-recovery equipment used is compatible with the HVAC subsystem wherever possible. The burning schedule of the solid wastes conforms to the requirements of the HVAC subsystem. The utilization of supplemental fuel in the incineration process is minimized, and the stack emissions comply with EPA guidelines.

All solid waste used is from the community itself; preincinerated solid wastes are not imported to or exported from the community. Intracommunity transportation of solid wastes from one MIUS facility to another is permitted when required. Alternate disposal or storage is provided for protection from the possibility of subsystem failure. The ultimate disposal (in the form of ashes) is, however, to a remote, extracommunity landfill.

Water Subsystem Criteria

All water obtained from the water source is treated so that it meets the 1962 U.S. Public Health Service standards for drinking water. Only such potable water is used for human consumption. Domestic hot water is obtained by using prime mover waste heat wherever possible to heat potable water.

Wastewater treatment produces an effluent that can be used in heat rejection; that is, the effluent is of

sufficient quality for use in heat exchangers and cooling towers. Human contact with treated effluent is minimized; however, surplus treated wastewater may be used for lawn watering.

Throughout the potable and wastewater portions of the subsystem, alternate means of disposal or storage are provided in case of subsystem failure. Adequate pressure and storage of water exist for firefighting purposes at any location within the community. Appendix B contains supportive data for the MIUS conceptual design.

CONVENTIONAL SYSTEMS DEFINITION

Conventional utilities service a community through independent networks and systems. To determine whether an MIUS system would be beneficial to a community, a conventional utility services network was defined for comparison with the MIUS (fig. 3). The defined conventional utility systems provide services in a manner similar to those of the model community, Columbia, Maryland.

Power Generation and Distribution

The reference conventional power generation and distribution system for the community study is a 1300-megawatt, diesel-fuel-oil-fired steam powerplant with an average plant thermal efficiency of 32.7 percent. The plant is assumed to be grid connected and located in the east-central region of the United States. Condenser cooling is accomplished by a combination of reservoir water and natural-draft cooling towers.

The power transmission system is assumed to be a conventional 700-kilovolt system (grid) with stepdown to 230 kilovolts at a main substation in the vicinity of the community site. Figure 4 shows the transmission system used for providing power to the primary feeders of the community distribution system. Within the community, three satellite substations are serviced by overhead transmission lines; transmission is from the grid to the main substation to the three satellite substations. The transmission conductors are composed of noninsulated aluminum.

The average power transmission efficiency is assumed to be 95 percent. Power is distributed through 13.2-kilovolt primary feeders (insulated copper conductors) installed underground. This arrangement is typically used in current developments. Local transformers (50 to 80 kilovolt-

amperes) are used to step down voltage to 120/240 V ac for domestic use. The average distribution efficiency is assumed to be 97 percent. The electrical design transmission equipment within the community required for the conventional system is as follows.

1. Substations

   a. Main substation A - 326 886 kilowatts

   b. Satellite substation B - 83 164 kilowatts

   c. Satellite substation C - 77 394 kilowatts

   d. Satellite substation D - 83 164 kilowatts

2. Wire size and length

   a. 500 MCM - 39 502 meters (129 600 feet)

   b. 400 MCM - 13 167 meters (43 200 feet)

   c. No. 2 (ground) - 23 652 meters (77 600 feet)

3. Transformers and switchgear

   a. One - 200 000 kilowatts

   b. One - 100 000 kilowatts

   c. One - 30 000 kilowatts

   d. Nine - 25 000 kilowatts

   e. Two - 10 000 kilowatts

The distribution equipment is as follows.

1. Wire size and length

   a. 500 MCM - 1 406 926 meters (4 615 900 feet)

   b. 400 MCM - 136 698 meters (448 485 feet)

   c. 1/0 - 514 348 meters (1 687 495 feet)

2. Transformers

   a. Seven - 6000 kilowatts

   b. 10 816 - 50 kilowatts

3. Switchgear - 676 to 800 kilowatts

4. Average power factor - 9

Heating, Ventilation, and Air-Conditioning Systems

The conventional HVAC system was defined for each building type. In a conventional system, each building has an independent HVAC system (some form of a central system). In most systems, ducts are used to transport the conditioned air throughout the facility; however, in other systems, hot or chilled water is transported through a two-pipe or four-pipe system.

In a two-pipe system, one pipe is the supply and one is the return. Either hot water or chilled water can be distributed, but simultaneous distribution is not possible. A four-pipe system allows hot and chilled water to be distributed simultaneously with the hot water using two pipes, a supply and a return, and the chilled water using the other two. The HVAC systems for various facilities are defined in table 1.

Water Supply System

Water for potable water use and firefighting comes from surface source water 24 kilometers (15 miles) from the community. The water is piped to a central treatment plant, treated, and then distributed to the community users in the same manner in which water is distributed in a 29-MIUS option (option I) facility. (Option I and the 8-MIUS facility (option II) are explained in appendix B in the section entitled "Design Strategy.") Water for firefighting is distributed in the same manner, with elevated water towers used to meet storage requirements. The water supply distribution pipe sizes and lengths are listed in table 2.

Wastewater Treatment and Solid-Waste Management

The wastewater treatment for the community is accomplished in a central plant. The wastewater is fed to the central plant by conventional gravity flow through trunks and interceptors. The distribution pipe sizes and lengths required for the conventional system are listed in table 3.

The solid wastes are collected and transported 24 kilometers (15 miles) to the air incinerator/landfill. The system is diagramed in figure 5.

COMMUNITY ENERGY ANALYSIS DATA

Energy analyses were performed for each separate community element (i.e., neighborhood, village center, etc.) and for the integrated complex at several points during the 20-year growth period. The Energy System Optimization Program (ESOP) (ref. 1) was the primary tool used for these energy analyses and for MIUS load determinations. This section of the report describes the techniques used both for load and energy analyses, discusses the energy analysis data formats and the special assumptions made for the various analyses, and presents all the energy analysis data developed for the entire community study. The ESOP consists primarily of subroutines that model each of the MIUS subsystems and are integrated with subroutines that predict HVAC and water system loads. The program is divided into five general analytical components plus input/output components as shown in the generalized ESOP analysis schematic presented in figure 6.

Solid-Waste Disposal

The waste disposal calculation section of the program predicts the daily total energy required to operate a specific waste disposal system (for a given trash load) and the daily quantity of usable waste heat energy that is recovered from the specific disposal process.

Heating, Ventilation, and Air-Conditioning Loads

The HVAC loads calculation section of the program predicts hourly heating and cooling loads of the buildings to be serviced by the MIUS as a function of indoor and outdoor air conditions, solar effects, building construction and geometry, domestic electric power profiles, and occupancy profiles. These loads are calculated for each building type and totaled for the entire complex to obtain a total 24-hour load profile for each seasonal analysis.

Energy Requirements

The energy requirements calculation section of the program determines the hourly, daily, seasonal, and annual energy requirements for the MIUS complex. Load information from the HVAC loads section, heat recovery and fuel requirement data from the solid-waste section, and waste heat data from the power generation section are used to determine energy utilization and requirements for HVAC

equipment, boilers, cooling towers, etc. Thermal storage is an optional feature in this section of the program.

Power Generation

The power generation calculation section of the program is used to determine the energy required for specific prime mover systems to provide required electrical power as defined by the energy requirements section. The power generation section also defines (for the energy requirements section of the program) the amount and type of waste heat available from the prime mover system. The interface between these two sections of the program accounts for electrical power demands created by the compression air-conditioning required to supplement air-conditioning provided by waste heat.

Conventional Utility System

The conventional utility system calculation section of the program is used to determine the energy required by a conventional commercial utility system to provide the same services as those provided by the MIUS. The conventional system consists of a central power generation facility, all-compression air-conditioning, and a gas-fired boiler for space heating and hot water heating.

The ESOP Output

In general, ESOP output consists of (1) the operating characteristics and recoverable waste heat energy of the solid-waste disposal systems, (2) all components of the heating and cooling loads, (3) the load demands, operating characteristics, and energy requirements of the specific prime mover being analyzed and an indication of the degree of utilization of waste heat energy, and (4) a summary of daily, seasonal, and yearly energy requirements of the specific MIUS configurations required. Input and output parameters are listed in appendix B in the section entitled "Subsystems Design Tasks and Logic Flow." Community energy analysis supportive data are given in appendix C.

ADDITIONAL MIUS ANALYSES

Various additional analyses conducted relative to the MIUS conceptual design concerned thermal balancing, thermal sizing, steam powerplants, an electrical option for option

II, pyrolysis, vacuum collection of wastewater, use of heat in wastewater treatment, water-saving techniques and indirect water reuse, removal of sulfur dioxide from power generation stack gases, and a data processing alternative for the MIUS control and monitoring subsystem.

The first four areas of investigation did not yield substantial benefits; however, analyses of the remaining six items indicated the possibility of substantial improvement in the overall performance and/or economic advantage of MIUS.

Thermal Balancing

The objective of thermal balancing was the recovery of sufficient heat within the MIUS plant to support all heating and air-conditioning requirements. The necessary heat was obtained by incinerating additional refuse in sufficient quantities to provide the required heat through the incinerator heat-recovery system. Thus, heat requirements were met in one MIUS location by incinerating refuse from another MIUS location. For example, CBD MIUS heat requirements were met by incinerating all refuse collected in the total community. The result was a 2-percent decrease in thermal efficiency and a 1-percent increase in fuel consumption for the community in option II.

Thermal Sizing

As in the thermal balancing analysis, the objective of thermal sizing was the recovery of heat within the MIUS to support all heating and air-conditioning requirements. The additional heat for this analysis was obtained by operating the prime movers at a level that provided the required heat through the heat-recovery systems of the prime movers; thus, all the heat requirements of the MIUS were met. Excess power was supplied to the grid. The heat requirements of an MIUS for an average summer day were met for both the village complex MIUS and the CBD MIUS in option II. Each village complex MIUS then supplied 25 megawatts of excess power, and the CBD MIUS provided 75 megawatts of excess power to the grid.

Steam Powerplants

A steam plant design for the community MIUS was defined to replace the diesels. It was compared to a conventional system to determine fuel savings (table 4). The results indicated that there were no significant fuel savings with

option II (4.9 percent), and with option I, the fuel savings were negative (-5.6 percent).

Electrical Option for Option II

Possible energy savings resulting from supplying a portion of the village complex electrical load from the CBD MIUS were investigated. The results showed no significant change in energy savings with the same utilization of recovered heat. The annual fuel savings for the baseline community is 37.86 percent as compared to a 37.69-percent savings in the electrical option community.

Pyrolysis

Pyrolysis may be defined as destructive distillation in the absence of oxygen or other oxidants. Pyrolysis of solid waste has been demonstrated in several instances. The Bureau of Mines (ref. 2) has presented test data concerning the types of products to be expected from pyrolysis of municipal waste. Using pyrolysis to process 907 kilograms (1 ton) of municipal solid waste produces the following products: (1) 502 cubic meters (17 741 cubic feet) of gas with heating value 16 649 kJ/m^3 (447 Btu/ft^3), (2) 18.14 kilograms (40 pounds) of tar with heating value 3731 kJ/kg (1605 Btu/lb), (3) 69.85 kilograms (154 pounds) char with heating value 12 227 kJ/kg (5260 Btu/lb).

These products are produced by operating the pyrolysis process at 1173 K (900° C) and 101 325 N/m^2 (1 atmosphere). By varying temperature and pressure, yields of various products may be increased or reduced.

Three pyrolysis options were considered. In the first option, pyrolysis gas is used to heat hot water and to provide space heating for the single-family dwellings. In the second option, pyrolysis gas is fed back into the system to be used in generating electrical power. In the third option, pyrolysis gas is used to heat hot water for the single-family dwellings and to provide the energy source for cooking in all dwelling units within the village complex. Also, the remaining gas is supplied to the power generation subsystem in the CBD MIUS.

Vacuum Collection of Wastewater

Normally, gravity is the force used in the collection of wastewater and the transfer of that water through interceptors and sewers to the treatment facility. An

applied vacuum of 50 662 to 60 795 N/m^2 (0.5 to 0.6 atmosphere) was used in this analysis to accomplish the transfer.

The use of vacuum collection permits installation of the sewers in a shallow trench that follows the ground profile; thus, the sewer is generally above the water table. Smaller pipe (7.6 by 10.2 centimeters (3 by 4 inches)) is used in the force main configuration. The polyvinyl chloride (PVC) pipe used is virtually leakproof, and, if a break does occur, the leakage is inward and manholes for the discernment of breaks are eliminated. Also, there are significant capital cost reductions.

The system does have disadvantages. Code revisions and local health department review and approval of the system are required. Because the system is mechanical, more maintenance is required. The vacuum collection design requires specialized knowledge; thus, design costs are somewhat higher. Operating experience with such a system in the United States is limited; however, the technology is now available.

The neighborhood and village center complex in option II requires three vacuum stations, one in each of the three neighborhoods.

Use of Heat in Wastewater Treatment

Sludge drying and influent temperature stabilization are two specific uses of excess heat energy that were examined.

The objective of sludge drying was to use excess high-grade heat, thus eliminating the need for the sludge incinerator. This process was accomplished by using a heat-exchange system downstream of the sludge dewatering equipment proposed in the baseline design. Fuel savings resulting from this sludge drying technique were 3.656 m^3/day (965.7 gal/day) for option I and 3.758 m^3/day (992.8 gal/day) for option II.

Excess high- and low-grade waste heat can be used to stabilize the wastewater treatment plant influent temperature. This technique was accomplished by using a heat-exchange system installed upstream of the initial plant process. Temperatures greater than 311 K (100° F) can be maintained throughout the year. The quality of the treatment plant effluent is stabilized. Additionally, plant sizes may be reduced because of the increased efficiency of the treatment process.

Water-Saving Techniques and Indirect Water Reuse

The objective of this analysis was to determine the effect of the selected reuses (HVAC rejection, engine oil cooler heat rejection, lawn watering and irrigation, and firefighting) on reclaimed water quality with respect to dissolved solids content and holding time for loads using no water-saving devices. Using the conventional flow (no special water-saving devices) in option II, the annual dissolved solids buildup factor is 1.14 with a retention time of 168 days. With water-saving devices (10 percent toilet), the buildup factor is 1.22, and the retention time is 298 days. With a 10-percent toilet and 10-percent shower, a retention time of 438 days results in a buildup factor of 1.29. These results indicate that dissolved solids present no problems.

Because of the long retention time and reliable tertiary treatment, lake water recycling for potable use is feasible.

Removal of Sulfur Dioxide

The Los Angeles Power and Electric Company has collected test data on the use of water to scrub sulfur dioxide from their power generation stack gases. The Lin-Pro Corporation has developed and tested a water purification system that uses sulfur dioxide to produce water of potable quality. Using the data from these applications, a wastewater treatment system could be developed for the MIUS that would utilize the sulfur dioxide in the power generation stack gases for the treatment of the wastewater.

Wastewater scrubbing of stack gases offers potential simultaneous improvement in wastewater treatment and air quality.

Data Processing Alternative for MIUS Control and Monitoring Subsystem

The purpose of the data processing alternative analysis was to determine other uses of the computer that controls the MIUS. It performs the central station utility data processing functions of logistics, maintenance, utility billing, and resource allocation. It can be sized to accommodate the needs of the entire community for large-scale data processing. Such functions as municipal taxation; payroll figuring; hospital and insurance accounting; engineering computations; banking, savings, and loan functions; credit account functions; and scientific

support for research and the college could be performed for elements within the community.

The system incorporates the following equipment: (1) central processing unit (2-megabyte memory), (2) mass storage (four disks, 800 megabytes total), (3) six magnetic tape units, (4) two high-speed printers, (5) card reader-punch, and (6) terminals and special purpose equipment for users.

The computer time can be sold as a "utility." It can be time shared, with rent based on central processing unit second and mass storage usage and total connect time. The revenues can be included as MIUS income.

ENVIRONMENTAL IMPACT

The use of MIUS to support a new community has environmental advantages and disadvantages. In general, the advantages seem to outweigh the disadvantages.

The local generation of power increases the amount of local air pollution. However, a study of these emissions indicates that local concentrations can be kept within Federal Air Quality Standards. On a regional basis, the MIUS emission rates exceed the limits set forth for the 1985 time period, but the conventional powerplant also exceeds the 1985 limits. The total weight of pollutants released to the atmosphere is nearly equivalent for both systems; however, MIUS provided a 40-percent fuel savings. Reduction of emissions may be feasible for both conventional and MIUS systems.

The MIUS uses approximately 40 percent less water than a conventional system, but 10 to 20 percent more dissolved solids are discharged into adjacent streams. The community MIUS may be independent of an outside water source. Thermal pollution of adjacent streams does not appear to be a significant problem.

The use of MIUS in a community will raise the ambient air temperature, but the possibility of additional fuel savings as a result of this increase in air temperature has not yet been determined.

Equipment for MIUS could create some additional noise, but sufficient design data are available to ensure that it will meet the Department of Housing and Urban Development noise criteria.

The purpose of this report is not to present an environmental statement for the community but to point out those areas of consideration that are unique and peculiar to MIUS. Comparisons between MIUS and alternate facilities are presented in appendix D.

COSTS

The costs analyses are as necessary to the design of an MIUS as the engineering design. For MIUS to be practical, it must be economically competitive. In fact, evidence of cost savings will entice potential users to take advantage of the other benefits of the MIUS concept.

Appendix E contains detailed information concerning the MIUS cost analyses, which were based on the designs previously described. Note the excessive costs of the electrical subsystem (approximately 45 percent of the total MIUS costs and 55 percent of the total conventional costs).

The consumables savings that resulted from the use of each MIUS option when compared to a conventional utility system are shown in table 5. Economic analysis indicates that the total cash outlay and the operation and maintenance costs for the two options were considerably less than those for a conventional system (table 6).

Both MIUS options show considerable savings over the conventional system, with option II slightly better than option I. In 1973 dollars, over the 20-year period ending in 1994, the total cash outlays for options I and II are $56 and $94 million less than the conventional system, respectively. When the costs are escalated and discounted, the cost savings are $18 and $34 million and the percent savings are 7.5 and 14.1, respectively, assuming fuel costs escalated at 5 percent/yr. If the fuel cost escalation was 15 percent/yr., the escalated and discounted cost savings would be $78.5 and $94.4 million, and the percent savings would be 19.7 and 23.6.

The MIUS not only reduces the amount of energy required and saves valuable natural resources but also competes economically with today's conventional systems.

SUBSYSTEM COSTS

The analyses of MIUS utilities and services indicate that they are cost competitive with conventional utilities

and services for large, new-community applications. Cost escalations and discounted cash-flow analyses, as compared to current costs, do not significantly affect the conclusions obtained from the study. A breakdown of the cost summary within each subsystem is shown in appendix E.

In the electrical power subsystem, a major cost saving will result from reduced fuel requirements and electrical transmission facilities. The reduced water supply requirements also produce a major cost savings.

The capital and operating costs of small wastewater treatment plants are not offset by reduced collection costs, but the capital and operating costs of a local, intermediate-sized treatment plant may be cost effective because of reduced collection costs. Solid-waste collection and handling costs are not reduced significantly; however, the recovery of energy from solid waste appears to be economically desirable. The increased capital costs of the large central air-conditioning systems are offset by reduced maintenance costs.

CONCLUDING REMARKS

The Community Conceptual Design Study was performed to determine the applicability of the MIUS concept to a new satellite community of 100 000 persons. The analysis indicated that considerable resource savings could be obtained by using the MIUS instead of a conventional method of providing utility services. Two MIUS design options were considered -- one containing 8-MIUS facilities and one containing 29-MIUS facilities.

The design baseline does not incorporate a high level of optimization; however, several additional techniques were evaluated that could substantially improve overall MIUS performance and economic advantage. For example, the use of a vacuum waste collection system has the potential for reducing capital costs and treatment plant size. If pyrolysis, presently in the pilot development stage, were used for trash processing in the community, an additional 18.6-percent MIUS fuel savings could be achieved over and above the 38 percent achieved in the design baseline. The use of 10 percent water-use toilets and showers in the community buildings will result in a 50-percent reduction in water requirements. Also, wastewater scrubbing of stack gases offers the potential of improving air quality by removing sulfur dioxide while simultaneously aiding in the wastewater treatment process.

Although MIUS is economically advantageous, some aspects of the design warrant further investigation. The MIUS designs considered in this report showed an increase in certain types of air pollutants (particularly oxides of nitrogen) such that it would be difficult to satisfy the 1985 emissions standard. Also, the derived MIUS design uses spray ponds instead of cooling towers, which poses the potential problem of water vapors rising from the ponds during certain climatic conditions. In addition, the use of a conventional biological sewage treatment plant has an impact on community land allocation because of its size.

This study indicates that the MIUS concept is capable of supporting a community of 100 000 persons while conserving natural resources without adversely affecting the physical environment.

Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas, April 16, 1976
386-01-00-00-72

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2. Sanner, William S.; Ortuglio, C.; Walters, J. G.; and Wolfson, D. E.: Conversion of Municipal and Industrial Refuse into Useful Materials by Pyrolysis. BM-RI-7428, Bureau of Mines, Energy Resource Center, Pittsburgh, Pa., Aug. 1970.

TABLE 1.- THE HVAC SYSTEMS FOR VARIOUS BUILDING TYPES

Facility	Air distribution	Heating	Cooling	Hot water
Single-family dwellings	Single air duct (no return duct), single zone control	Electric heat pump[1]	Electric heat pump	Electric hot-water heaters
Townhouses	Not applicable	Electric strip heater	Multiroom through-wall central compression systems	Electric hot-water heaters
Garden apartments	Not applicable	Electric strip heater	Multiroom through-wall central compression systems	Electric hot-water heaters
Schools	Single air duct, multizone control	Boilers	Electric compression chillers	Boilers
Shopping centers	Dual air ducts (supply and return), multizone control	Boilers	Electric compression chillers	Boilers
Recreation centers	Two-pipe system, multizone control	Boilers	Electric compression chillers	Boilers
Medium- and high-rise apartments	Four-pipe system	Boilers	Electric compression chillers	Boilers
Office buildings .	Dual air ducts, multizone control	Boilers	Electric compression chillers	Boilers
College	Two-pipe system, multizone control	Boilers	Electric compression chillers	Boilers
Inns, hotel, and hospital	Dual air ducts, multizone control	Boilers	Electric compression chillers	Boilers

[1]Used to help balance the electrical profile.

TABLE 2.- CONVENTIONAL WATER SUPPLY EQUIPMENT

Pipe size, cm (in.)	Length, m (ft)
20 (8)	142 006 (465 900)
25 (10)	34 823 (114 250)
30 (12)	1 158 (3 800)
36 (14)	77 434 (254 050)
41 (16)	18 837 (61 800)
51 (20)	4 968 (16 300)
61 (24)	9 616 (31 550)
76 (30)	16 093 (52 800)
91 (36)	15 362 (50 400)
107 (42)	26 304 (86 300)

TABLE 3.- WASTEWATER DISTRIBUTION EQUIPMENT

Pipe size, cm (in.)	Length, m (ft)
20 (8)	28 400 (93 175)
25 (10)	3 307 (10 850)
30 (12)	183 (600)
38 (15)	5 974 (19 600)
46 (18)	2 667 (8 750)
53 (21)	13 731 (45 050)
61 (24)	1 021 (3 350)
69 (27)	1 052 (3 450)
76 (30)	884 (2 900)
84 (33)	1 463 (4 800)
91 (36)	1 753 (5 750)
107 (42)	1 829 (6 000)
137 (54)	1 463 (4 800)
152 (60)	2 195 (7 200)

TABLE 4.- ENERGY SAVINGS OF MIUS STEAM PLANT COMPARED

TO CONVENTIONAL PLANT USING HEAT PUMPS FOR

GARDEN APARTMENTS AND TOWNHOUSES

MIUS community component	Savings, percent				
	Winter	Spring	Summer	Fall	Average
Neighborhood	-9.5	-14.0	-6.9	-13.7	-11.0
Village center	8.0	.4	-.1	-.1	2.1
Village complex	6.1	4.0	5.7	4.2	5.0
Central business district	7.5	3.1	1.4	3.2	3.8

TABLE 5.- CONSUMABLES SAVINGS AND WASTE REDUCTION

RESULTING FROM USE OF MIUS OPTIONS COMPARED TO A CONVENTIONAL

UTILITY SYSTEM

Resource	Option I savings, percent	Option II savings, percent
Energy savings	37.86	38.02
Water savings	17.5	17.5
Effluent reduction	27.1	27.3
Trash load reduction	80.0	80.0

TABLE 6.- TOTAL CASH OUTLAY AND THE OPERATION AND MAINTENANCE COST FOR OPTIONS I AND II AND FOR A CONVENTIONAL SYSTEM

[For 1975-94 (1973 $)]

Expenditure	Conventional	Option I	Option II
Total capital outlay	273 884 000	255 877 000	238 930 000
Total operation and maintenance (including fuel)	316 258 000	279 458 000	256 949 000

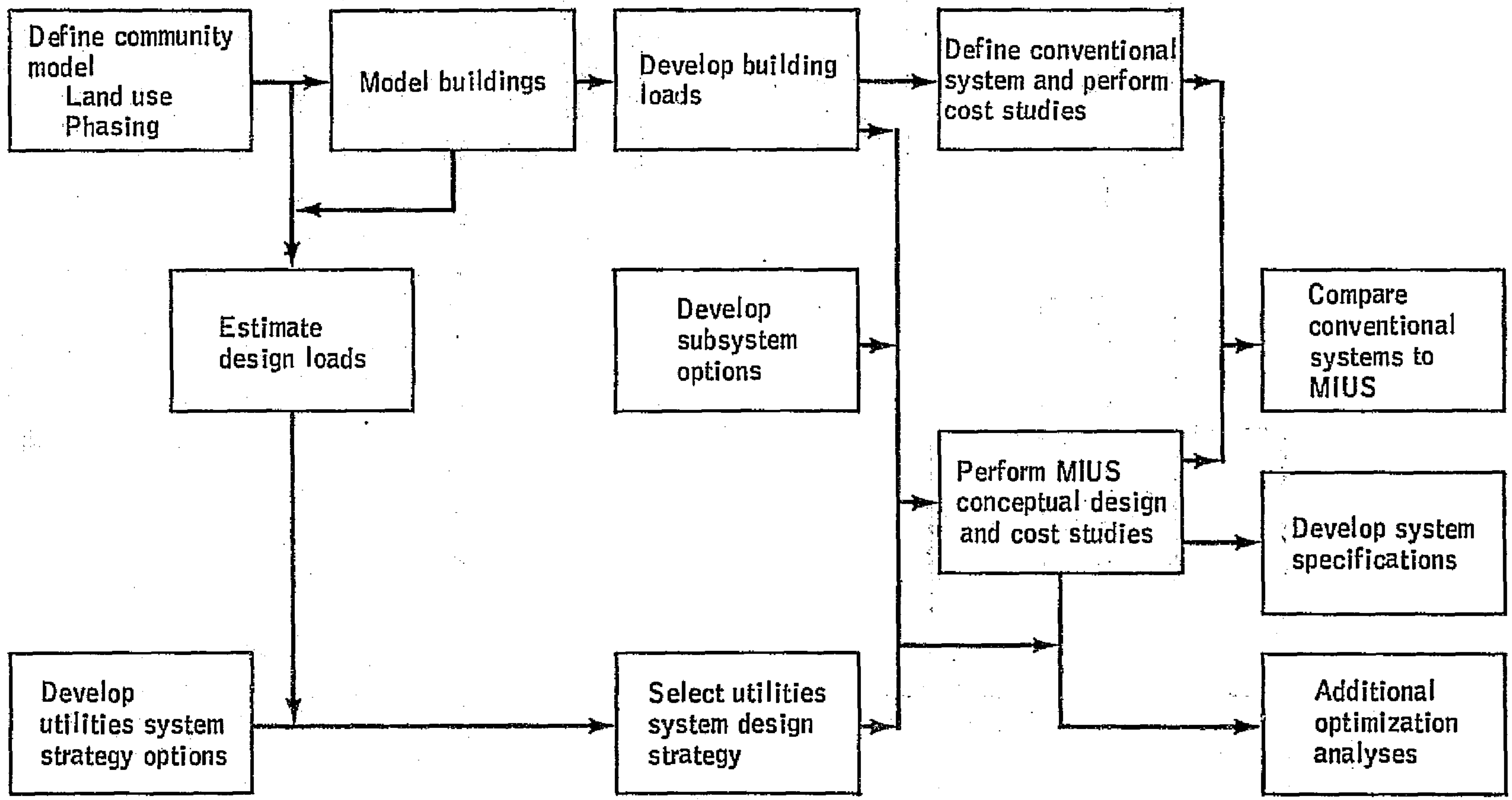

Figure 1.- The MIUS Community Conceptual Design Study logic.

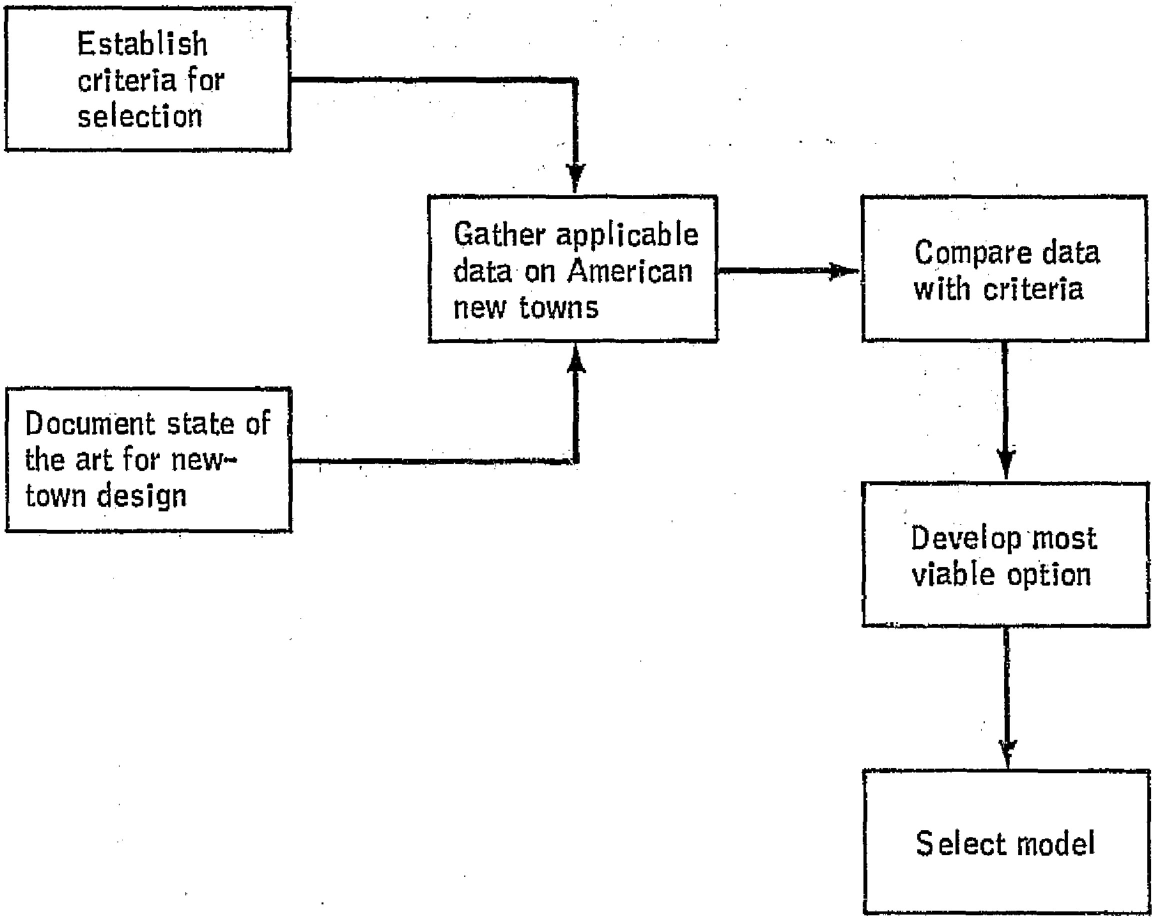

Figure 2.- New-town study model logic.

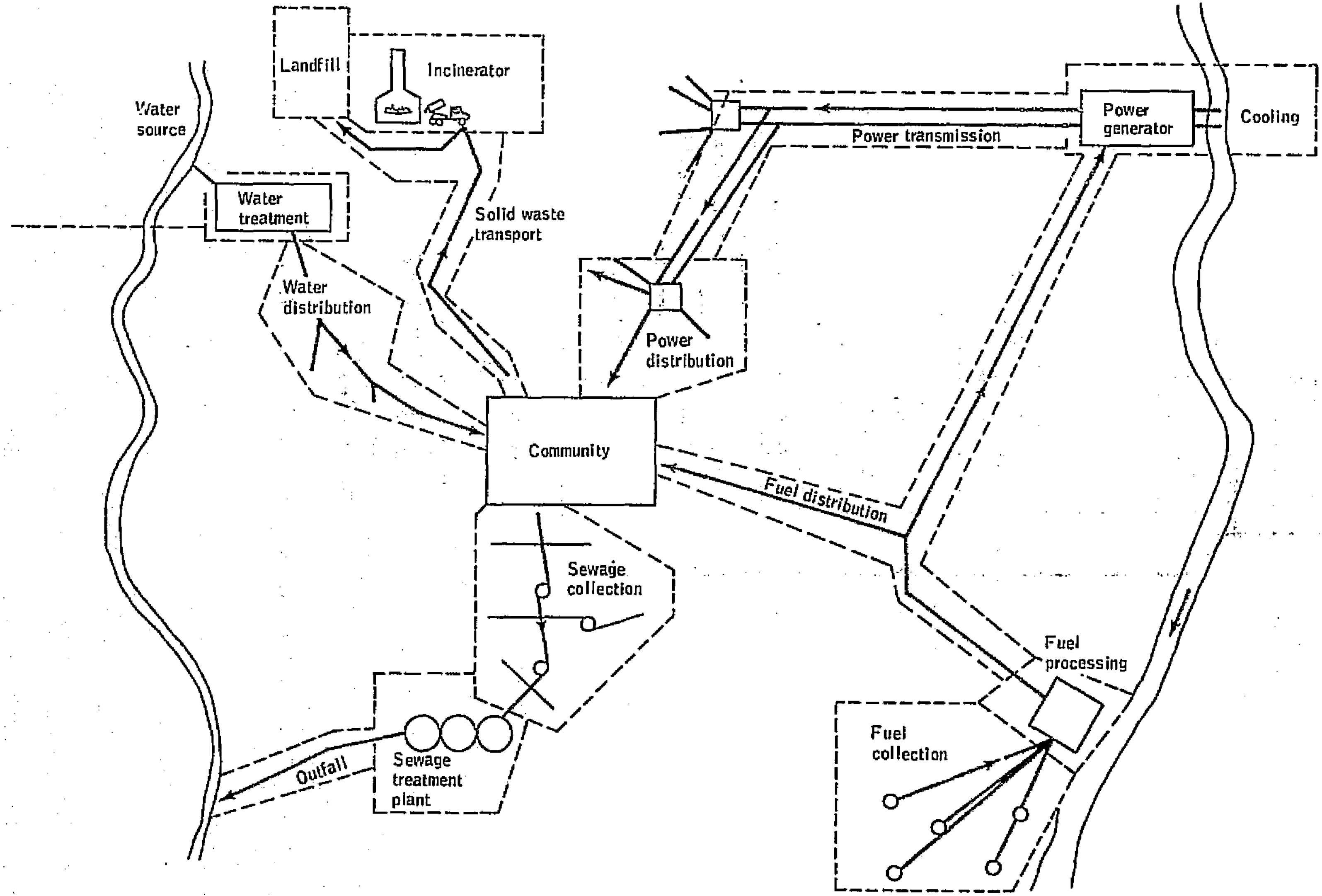

Figure 3.- Conventional utility services.

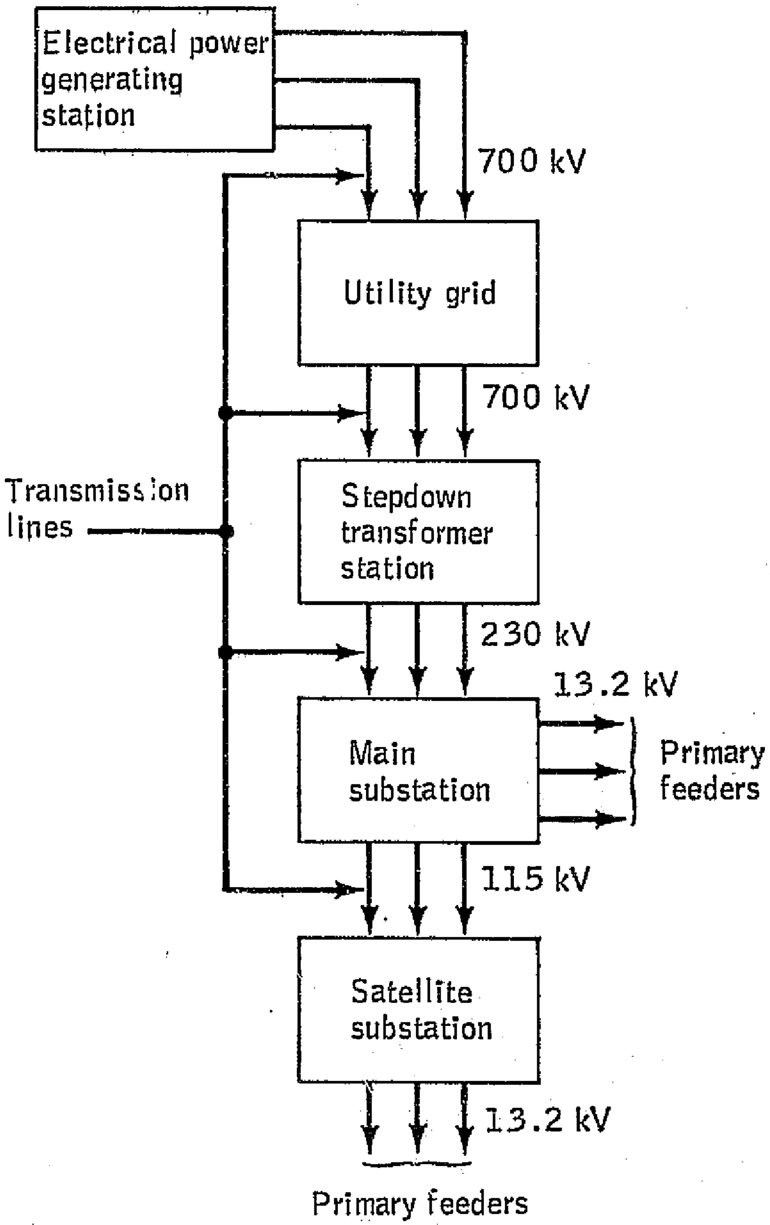

Figure 4.- Conventional electrical generation and transmission.

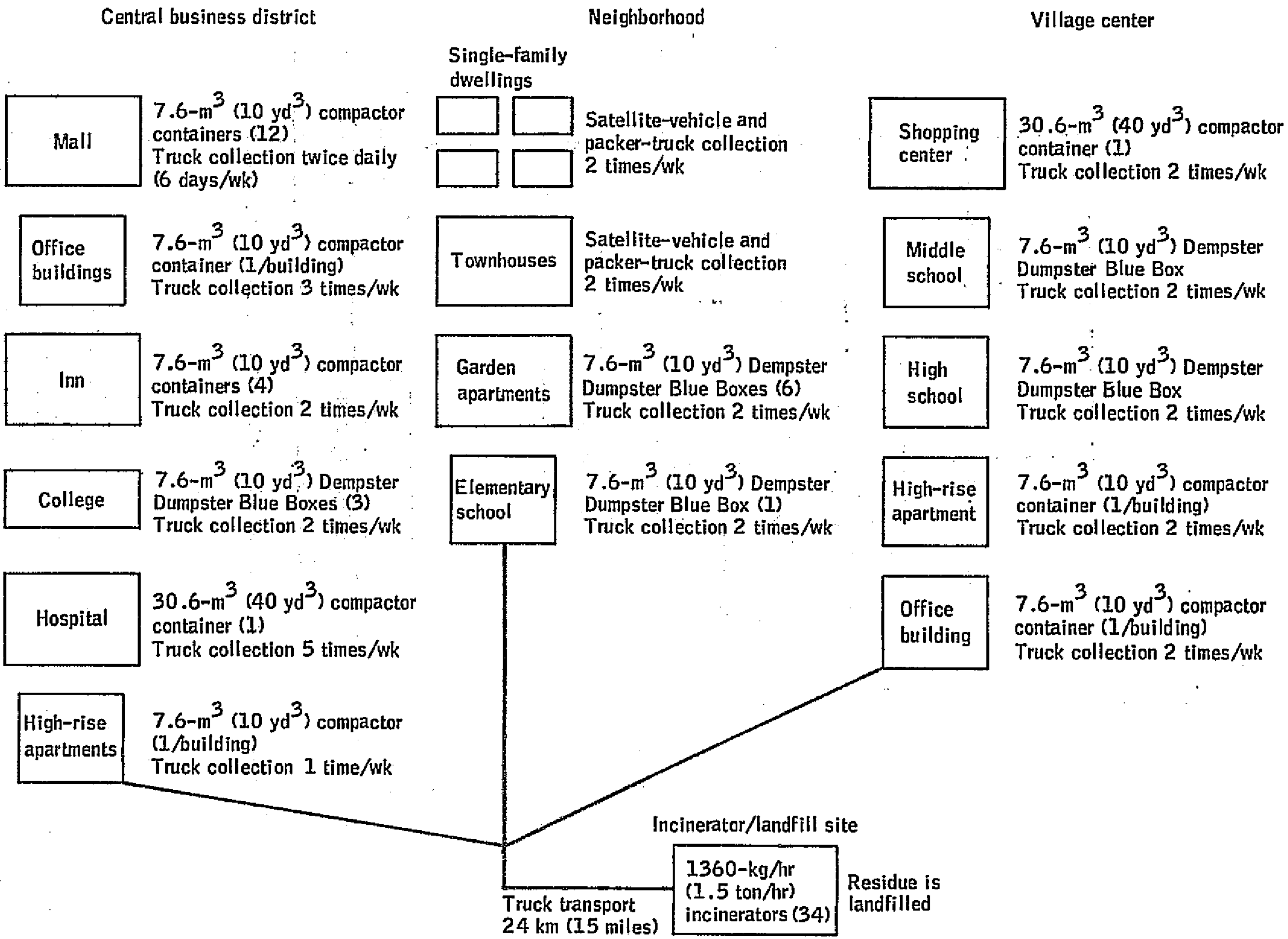

Figure 5.- Conventional solid-waste management subsystem.

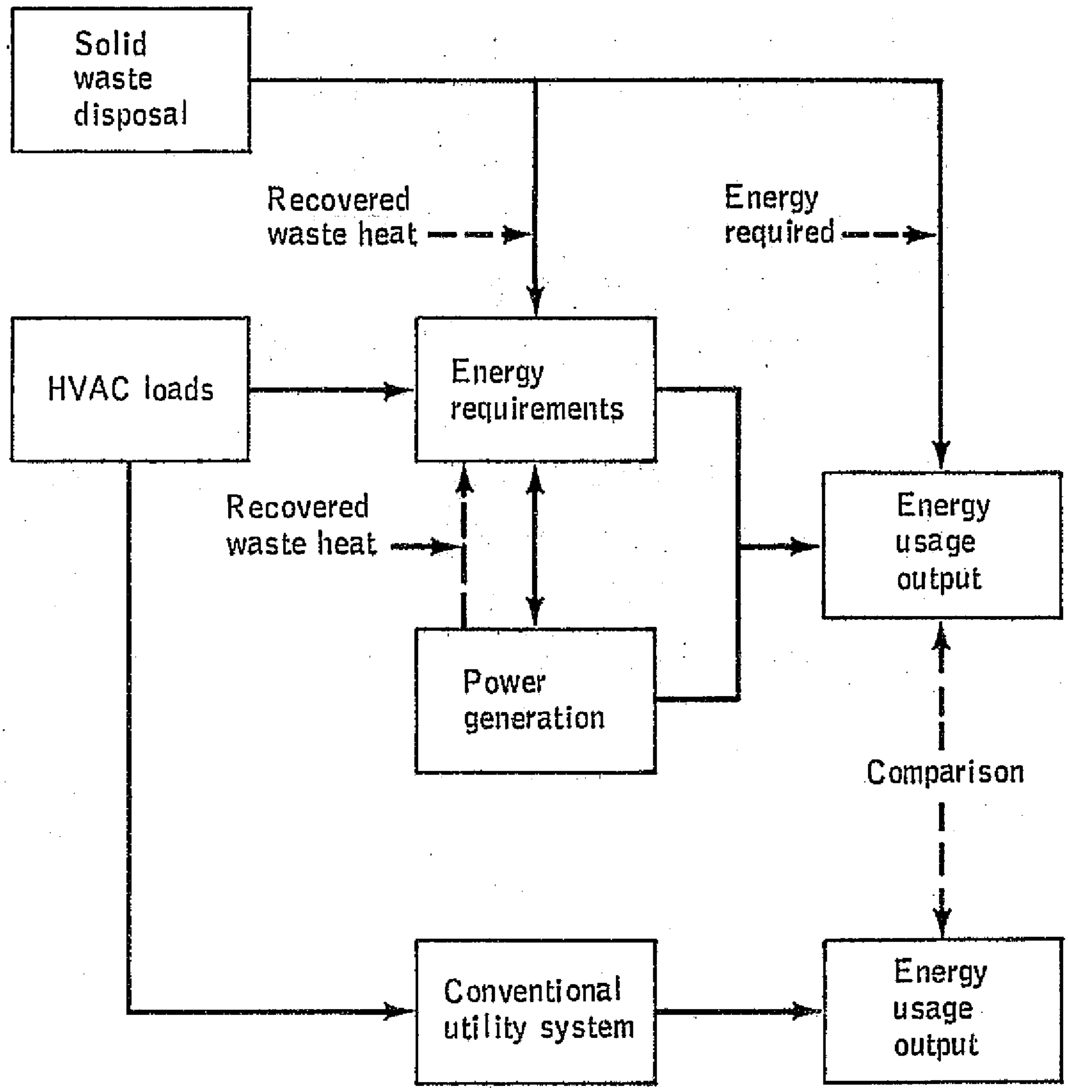

Figure 6.- Generalized ESOP analysis schematic.

APPENDIX A

COMMUNITY MODEL SUPPORTIVE DATA

NEW-TOWN DATA SURVEY FOR MODEL SELECTION

Criteria for Model Selection

Because climate affects the design of the modular integrated utility systems (MIUS), a region of "average" climate for the United States was selected for the location of the model. This climate was determined by averaging the degree-days of heating for each of the 14 new towns listed in table A-1.

The model selected had to represent the state of the art of new-town design; thus, the design had to contain new-community characteristics and basic-community structures and components that represented the state of the art. Data availability for the model was essential. Also, a reasonable phasing schedule for construction and a demonstrated growth pattern consistent with the planned phasing schedule were necessary.

State of the Art of New-Town Design

The distinguishing characteristic of a new town as opposed to a development is the inclusion in the plan of commercial, recreational, industrial, and institutional facilities to support the expected population. The plan includes a comprehensive development program to safeguard land use. Provisions are made for high-, medium-, and low-density housing, with no restrictions on the placement of a particular density in any special section of the new town. Implementation plans include an administrative body to operate and maintain the public service systems of the community.

The three basic community structures, or systems patterns, used in the design of new communities are designated as grid, linear, and radial. In the grid scheme, the town is arranged in an overall grid; the activity generators are at the midpoint of the block, and the intersections are left open. The linear-scheme town is usually arranged along a transportation system; the overall

layout is rectangular. Where the radial design is used, the town radiates from a central activity center.

The type of new town is determined by its surroundings. A new-town-in-town is a large-scale redevelopment of an area within an existing community. Satellite new towns exist within commuting distance of a major urban area; thus, the growth of the new town is economically dependent on the larger urban area. A freestanding new town, which is a self-supporting community, is not dependent on an existing urban center. Growth-center new towns are built around an existing town, generally one not growing or one that is decaying, with the existing town as the core of the new town.

Characteristic building blocks, or components, are present in each type of new town. The basic component is the neighborhood. Neighborhoods are combined to comprise a village. The village center consists of some businesses and shopping facilities for the village. The villages surround the central business district (CBD) of the new town. The CBD contains major shopping, commercial, and service-oriented facilities. A separate industrial section is the job center for the inhabitants of the new town.

Model Selection

A survey was made of 14 prominent American new towns. Projected population, dwelling units, acreage, and population density were compiled to provide a determination of the average new town. The compilation of data is given in table A-1. The numerical averages of the data presented for the 14 new towns are given in table A-2. A comparison of the numerical averages with the surveyed new towns resulted in four candidates in the average range. These candidates were; (1) Columbia, located in Howard County, Maryland, approximately 32 kilometers (20 miles) northeast of Washington, D.C.; (2) Reston, located in Fairfax County, Virginia, approximately 29 kilometers (18 miles) west of Washington, D.C.; (3) St. Charles, located in Charles County, Maryland, approximately 40 kilometers (25 miles) southeast of Washington, D.C.; and (4) Park Forest South, located in Will County, Illinois, approximately 48 kilometers (30 miles) south of Chicago, Illinois.

These four new communities were then evaluated for compliance with the selection criteria (table A-3). A value was assigned to each criterion to represent its relative importance. Each new town was rated high, medium, or low in each category by judging compliance with that particular criterion. The value of the category was multiplied by the

compliance judgment factor, thus assigning values to the criteria of average climate, design state of the art, size, projected population, projected number of dwelling units, population density, dwelling-unit density, building mix of the design, and phasing schedule consistency. The numbers were totaled, and the town with the highest compliance total -- Columbia, Maryland -- was selected.

Columbia is a satellite new community with a radial design. Its demonstrated growth pattern is consistent with its planned phasing schedule. Columbia is the best known American new town having state-of-the-art design and excellent data availability.

SATELLITE NEW-TOWN COMPONENTS

The components of the new-town model used for this study are idealized components of the radial-scheme design of Columbia, Maryland: the neighborhood, the village, the village center, and the CBD. One of the major factors in such design is the placement of various services -- schools, shopping, health clinics, employment, etc. -- in relationship to the basic unit, the household. Design is predicated on walking distance from the household to the various services. Figure A-1 shows the distance and time for walking to such facilities and services.

Neighborhood

The concept used for the neighborhood is a combination of Clarence Perry's and Clarence Stein's neighborhood schemes (ref. A-1). Figure A-2 shows the detail of the neighborhood. The design is such that the elementary school for the neighborhood and its associated community facilities are within a 0.8-kilometer (0.5 mile) radius of the outlying homes, the homes farthest from the facilities. In this radial design, it is not essential to have such an exact shape (a 0.8-kilometer (0.5 mile) radius), but the design is best when all sides are a fairly equal distance from the center. Such a neighborhood must contain enough people to support one elementary school. To maintain the neighborhood quality, the interior streets should not be wider than required for the specific type of access to each house, to shops, and to the village center. This design must have guaranteed open spaces with approximately 10 percent of the neighborhood area in parks and recreation.

A neighborhood contains a variety of housing types and densities. Single-family detached houses are clustered (the majority around cul-de-sacs) to provide maximum usable open space. Townhouses and garden apartments are placed nearest the community center and in one section of the neighborhood.

The proposed population sizes of such neighborhood designs range from 275 to 3000 families. The number of families in a neighborhood depends on the development schedule of the new community and usually is approximately 1500 families. The model neighborhood for the study has 1361 families.

The major components of a neighborhood are the elementary school (one in each neighborhood), the open space with parks and recreation, pedestrian ways, vehicular avenues, and housing. The neighborhood components modeled for this study are 713 single-family detached housing units and 648 multifamily housing units. The multifamily units consist of 324 townhouse units and 324 garden apartment units. The average population of each neighborhood after development is 5000 people. The developed acreage per neighborhood is 134.4 hectares (332 acres). Open space consists of 13.4 hectares (33 acres): 8.9 hectares (22 acres) unstructured open space and 4.5 hectares (11 acres) devoted to parks. The total neighborhood area is approximately 147.7 hectares (365 acres).

Village

The major village components are the neighborhoods, the village center and park, and open space. As modeled for this study, each village will contain three neighborhoods and one village center (fig. A-3). The village concept is based on Stein's principle of three "interlocking neighborhood units" (ref. A-1). This arrangement provides "social extensive units" where residents have choices among different social groups. The village center, which serves as a hub of activity, includes office areas that provide decentralization from the CBD and enable working within walking distance of housing. Local retail for approximately 15 000 people is provided. In addition to housing in the neighborhood, a variety of housing types and densities and additional open space are included in the village (fig. A-4). The expected population range for the village is 4000 to 6000 families.

Village Center

The concept of the village center is a further development of Perry's and Stein's principles. Figure A-4 presents a layout of the village center of the model. Secondary schools form the hub of the center. The village commercial center provides basic facilities and rudimentary services related to homelife. Major recreational facilities are located in the village centers for communitywide participation; furthermore, a different type of recreation is provided in each village center. In this study, however, no differentiation will be made between villages; each will be treated as a duplicate of all other villages. In the village center, high-density residential housing exists near the village center. Religious facilities for village residents are also included.

The major components of a village center are secondary schools, retail stores, offices, service stations, religious facilities, recreational facilities, high-density housing, and open space and park areas. The high-density residential areas in the center provide the potential community resident with an additional choice in housing types and densities. This housing is near local retail, cultural, and employment facilities; thus, public transportation is not required. The proposed population range in the village center area is 300 to 400 families.

The village center modeled for this study contains one high school, one middle school, six medium-rise apartments, one village commercial center, one recreational building, two service stations (modeled for water use only), and religious facilities (assumed to be used during times that the commercial center is closed or operating on reduced loads).

All the village centers in the model community are identical. The land area of the center is 83.4 hectares (206 acres). Development within the center occupies 69.2 hectares (171 acres), leaving 14.2 hectares (35 acres): 10.1 hectares (25 acres) for park and recreation and 4.1 hectares (10 acres) for unstructured open space.

A summary of the local retail potential of the village center retail establishments appears in table A-4. This estimate was used to size the retail space for the village center.

Central Business District

The CBD (fig. A-5), the nucleus of the community, is the large service area for approximately 250 000 persons. Functionally, it connects communitywide services such as the hospital, college, offices, entertainment, and shopping.

The CBD contains regional shopping areas for the community. Office space in the CBD serves the market for the number of projected potential jobs and related activities. Community service functions such as government, police-protection, and fire-protection facilities are included in the office-area allotments. The model, Columbia, has a large amount of office space that reflects the type of jobs in its growth corridor. Hotel/motel accommodations are provided for visitors. Projected age-group studies demonstrate the need for a community college. High-density housing near the activity center increases the variety of housing and density choices for potential residents. A hospital is provided for communitywide health care. Such a community center must furnish space for other community service functions, a service station, and entertainment functions. A system of parks and open spaces connects the other components of the town to the CBD.

The CBD modeled for this study is composed of one regional shopping center, eight office buildings, one inn and hotel complex, one hospital, one community college, four high-rise apartments, four service stations (modeled for water use only), and a performing arts center. The retail commercial space for the study was determined from a summary of the retail commercial potential (table A-5).

The Conceptual New Town

The new community components previously described form the new town. The model for the study consists of 7 villages; each village contains 3 neighborhoods (a total of 21 neighborhoods) and the CBD. Figure A-6 shows the composite new town; figure A-7 depicts the detailed layout. The basic data concerning the conceptual model are given in table A-6. For the study, all neighborhoods and village centers are modeled similarly.

Major Economic Issues Influencing New-Community Design

The most important factor in determining the size of the new town and proceeding with development is a marketplace sufficient to sustain large-scale multiuse development --

that is, sufficient regional demand for land and a site location to attract the regional market.

Two factors are critical: (1) markets that are large in relationship to the size of the development and (2) the prospect of significant market penetration. A market penetration of 5 to 10 percent is possible. Thus, a metropolitan market with an overall housing demand of 10 000 units a year provides a 500- to 1000-unit market to support the financial needs of a new town. To achieve this goal, the designer must create strong, competitive, attractively designed, and effectively merchandised housing.

The essential financial measure for success is the time lapse between the investment of money at the onset and during the early years of development and the return of funds in the later stages. The economic feasibility threshold for such a project has been established at a pretax rate return of 15 to 20 percent.

Another major economic issue is the infrastructure cost. A reasonable goal in such a new community would be a 38-percent reduction in the per capita cost for infrastructure. For example, if it cost $1000 per capita to build streets, highways, water and sewer connections, distribuiton facilities, and other items, then the appropriate goal would be to deliver them for $620. The local government of the new community must generate, in a timely manner, enough tax revenues to support services such as schools, protection, general administration, roads, recreational programs, and health services.

Construction Phasing

The two major aspects of phasing are "how fast" and "where next." The most important single constraint is the rate at which the region surrounding the new town is growing. The amount of growth that will occur in this surrounding region places an upper limit on potential absorption.

Formulation of a phasing strategy is reduced to either balanced social and economic mix or balanced land use. A balanced social and economic mix is difficult to accomplish because economic and cultural prejudices exclude the poor. Balanced land use has a major economic factor working against it in the early phases. The residential absorption is a positive contribution to each flow, and, for a while, the commercial centers yield a negative net income. The developer can either sell the development rights on the first center or let the first residents be inconvenienced

until the positive cash flow can sufficiently finance the first commercial center. In the study model, the decision was made to "preservice the development." This strategy is illustrated in an estimated construction schedule (fig. A-8).

The phasing scheme for the community is shown in a detailed layout (fig. A-9). For this study, it was assumed that all three neighborhoods in each village would be developed simultaneously. Village A and village G are developed within 3 years, which means that each of the three neighborhoods within those villages are concurrently developed with the village according to the schedule shown in table A-7. The village centers for those villages follow the schedule in table A-8. The shopping center is constructed in the first year of the village development. The other villages (B, C, D, E, and F) are developed on a 4-year plan. Table A-9 shows the phasing of the neighborhoods within those villages. Table A-10 displays the village center phasing for those vilages. Again, the shopping center is activated in the first year of the village development.

The CBD is much more complex and contains many different facilities required at different stages of the community development. The first facility is activated during the second year of the community development schedule with completion during the 18th year (table A-11).

The projected population (fig. A-10) indicates the effect of the phasing schedule on the growth of the community. The fastest growth occurs in the first 5 years when the population increases to 10 000. The complete growth in 20 years yields a population of 110 000.

Building Types

A detailed description of the building types is required to allow preliminary engineering calculators to estimate utility loads and to establish the general character of the building types selected for the study. For each building type, important design areas were identified. After selecting the prime factor, a schematic plan was developed that reflected the areas of concern, code restrictions, and acceptable design standards. From the schematic drawing, a preliminary plan was developed according to the area requirements, vertical dimensions, and construction types. The plan was drawn in sufficient detail to provide the basic information for preliminary engineering calculations. The size of each building was derived from guidelines consistent with acceptable design standards based on the function and

market potential for each building type. The community design process established the number of potential occupants. That number specifies the building size, which is derived from standards established by codes and principles of good design.

The building parameters modeled for the study included facilities deviation, code classification, building usage area, vertical dimensions, building construction description, and an estimated occupancy profile.

Typical Construction Details

Typical cross sections (figs. A-11 and A-12) characterize the construction types of the representative buildings necessary for determining load factors. The number of types was limited to five for walls (fig. A-11) and two for roofs (fig. A-12) to minimize combinations and still provide a range of construction materials used.

Single-Family Dwelling Facility Description

The single-family dwelling selected to characterize the low-density housing of the town was abstracted from a Housing and Urban Development (HUD) report (ref. A-2). The house model was developed from a statistical survey of housing in the Baltimore-Washington, D.C., area and is intended to be used solely as a tool to estimate utility demands. All the single-family dwellings in the new-community model are described in table A-12. The dwelling design conforms to the uniform building code (UBC) classification I standards (dwellings and lodgings) (ref. A-3). Figure A-13 depicts the floor plan of the single-family model.

Townhouse Facility Description

The townhouse selected to represent this dwelling type in the medium-density housing areas of the new town was abstracted from a HUD report (ref. A-4). The townhouse model was developed from a statistical survey of multifamily housing in the Baltimore-Washington, D.C., area and is intended to be used solely as a tool to estimate utility demands. The townhouse has the same UBC classification as the single-family dwelling (ref. A-3). Table A-13 lists the descriptive data on the model townhouse. The floor plan of the model is shown in figure A-14. To determine the heating, ventilation, and air-conditioning (HVAC)

requirements, the occupancy profile was determined for all townhouses in a village (fig. A-15).

Garden Apartments Facility Description

The garden apartments (fig. A-16) were designed alike for all neighborhoods. The areas of primary importance in the design and arrangement of garden apartments include the circulation of vehicular and pedestrian traffic, unit density per hectare, privacy and community relationships, reasonable maintenance, economic soundness, and modularity.

The design conforms to UBC classification I standards. Figure A-17 shows the floor plan for a 54-unit module. Six modules comprise one set of neighborhood apartments, and all the modules are similar. The occupancy profile (fig. A-18) for one apartment unit is the average occupancy and is used in calculating HVAC loads.

Elementary School Facility Description

The elementary school design is based on a neighborhood school concept that places an elementary educational facility within a 5-minute walking radius of every house in a neighborhood of approximately 5000. The size of the school is based on the ratio of school-age children in kindergarten through the fifth grade, projected to be the national average in 1990 according to abstractions from the 1970 census report. Area requirements of the UBC were used for each type of functional area, and the design adheres to UBC classification C-1 standards. Table A-14 lists the descriptive features. The physical plant is designed to house 360 children and all necessary support personnel.

Of prime consideration in the design of such an elementary school (fig. A-19) is the compatibility with construction school design systems. This system includes flexible classroom space for team teaching, rapid construction, and less expensive interim financing because of performance specification systems, premanufactured components, and phase construction. The construction must be durable, and the design must provide for ease of supervision of student activities. There must be adequate food service and assembly spaces for educational and community uses. Finally, an acceptable relationship between the school and playgrounds and vehicular pickup areas must exist. Figure A-20 portrays the estimated occupancy profile for one neighborhood elementary school. The profile was used in calculating utility loads.

Village Center Commercial Facility Description

The size of the village center commercial facility (table A-15) is based on a combined regional and local marketing approach. It was designed on a 1.5-meter (5 foot) planning module or grid in a 9.1- by 9.1-meter (30 by 30 foot) structural bay format to allow for structural efficiency and compatibility of finish materials. The large area shown in figure A-21 was allocated for an activity generator of the village center shopping. This area is typical of the lease space for many national chain supermarkets. The adjacent 9.1- by 18.2-meter (30 by 60 foot) lease spaces are typical small-shop spaces and professional offices. The model design complies with UBC classification F-2 standards.

The location of the commercial facility is important. Access to major roads and to store service areas must be provided, and there must be proper circulation of pedestrian and vehicular traffic. The model design satisfies these factors. Utility-load calculations for the village commercial area were based on the estimated occupancy profile shown in figure A-22.

Recreational Building Facility Description

The recreational building, located in the village center within a 10-minute walk of the village inhabitants, is sized to serve a village of approximately 15 000 people and has the capacity to house an olympic-size swimming pool, an ice-skating rink, or several court games. The building shell is designed as a repeat module. There are seven recreational buildings, one for each village center. Four village center recreational buildings house olympic-size swimming pools; another building contains an ice-skating rink; another building houses a basketball court; and the seventh building provides space for other court games. Figure A-23 depicts the site and floor plans. The design complies with UBC classification B-4 standards.

When designing such a recreational building, consideration must be given to providing adequate dressing and toilet facilities for the building and, in the instance of the study model, the adjacent open park space. Food service and adequate storage space, sufficient parking and vehicular pickup facilities, and good pedestrian access must be included. A suitable relationship must exist between the building and the open park space. Figure A-24 displays the occupancy profile used in calculating the utility loads of the building.

Medium-Rise Apartment Facility Description

The medium-rise apartment buildings (six for each village center) were designed to provide an alternate living facility. The design adheres to the center corridor concept, which is well suited for a medium-rise structure. Various individual apartment layouts that provide a range of choices for the resident are available. This plan reflects the high-density ratio common to medium-rise apartments. These apartments have 10 floors of apartment units with 10 apartment units/floor (a total of 100 units/building).

The design and arrangement of medium-rise apartments must provide privacy for the residents. Structural efficiency is a major concern in such a design. Elevator core location must provide proper access to the apartments without wasting space. For our mobile society, the parking ratios are important. The design of the medium-rise apartments complies with UBC classification H standards (high-rise residential).

Table A-16 gives the descriptive data on the building. Figure A-25 illustrates the floor and site plan of one apartment building. Figure A-26 shows the occupancy profile used for calculating utility loads for one medium-rise apartment building.

Middle School and High School Facility Descriptions

The middle school and the high school (one each in the village center) are designed to serve a village population of approximately 15 000. The space requirements are based on the ratio of school-age children in grades 6 to 8 for the middle school and in grades 9 to 12 for the high school to total population, projected to be the national average in 1990 according to abstractions from the 1970 census report. Table A-17 lists the descriptive data for the middle school building, and table A-18 lists the data for the high school building. Area requirements of the UBC have been used for each type of functional area. The physical plant for each school building is designed to house 1140 students and all necessary support personnel. Figure A-27 depicts the floor plan of the middle school; figure A-28, the high school.

The schools are situated within a 10-minute walking radius of the village and are designed to be adjacent. Both schools have a similar-sized student body; furthermore, both schools share science laboratories, craft and art shops, assembly and performing arts spaces, and practice and playing fields. This consolidation of facilities provides

the student-body size necessary to support a wide variety of programs.

Compatibility with construction school design systems (the system used in the elementary school design) was a primary concern in designing both buildings. This system includes flexible classroom spaces for team teaching, rapid construction, and less expensive interim financing because of performance specification systems, premanufactured components, and phase construction. The design provides for durable construction. Adequate service and expanded educational facilities must be provided. Ease of supervision of student activities and entry and egress control of the physical plants are important design considerations.

Both buildings comply with UBC classification C-1 standards. The occupancy profile shown in figure A-29 is the same for both buildings. The chart was used to compute the utility loads for each school building.

Regional Shopping Center Facility Description

The size of the regional shopping center is based on a regional marketing approach. Table A-19 lists the building usage size, the vertical dimensions, and the construction description. This size commercial center is necessary to serve a satellite or freestanding community with a population of approximately 250 000. Figure A-30 shows the completed facility after 20 years, but the construction of the shopping center is modular. The center is activated a module at a time according to the phasing schedule (fig. A-8). One module is shown in figure A-31; three such modules exist in the completed center. Many shopping centers currently being planned are in the size range of one of the modules; thus, current information on design and construction was available. A shopping center of this magnitude can also support a variety of functions required to provide complete service to the community.

In the design and arrangement of a regional shopping center, location is important because there must be access to major roads. The design must provide good circulation of pedestrian and vehicular traffic and supply access to store service areas. Proper parking ratios for patrons are necessary. Modern marketing amenities are required to ensure continued consumer activity. Most important, the economic base must exist for the center.

The model regional shopping center complies with UBC classification F-2 standards (wholesale and retail stores,

offices, and drinking and dining establishments). The original occupancy profile was assumed to be that indicated by the dotted line in figure A-32; however, the refined profile defined by the solid line was used in calculating the utility loads.

High-Rise Office Building Facility Description

The office building used to represent the lease office space planned for the community is based on a recently constructed project that is representative of many speculative office buildings being built nationwide. Table A-20 lists the data for one tower or one office building. Figure A-33 illustrates two towers or buildings constructed as a set. The CBD contains four such sets, or a total of eight 12-story office buildings.

When an office building is being designed, a high efficiency ratio of rentable floorspace to the total floorspace must be considered. The floorspace should be easily divisible into small lease areas, if desired. There must be an efficient arrangement of core facilities, and parking facilities must be available in acceptable parking ratios to provide sufficient space for tenants and their customers.

The office building design complies with UBC classification F-2 standards. Figure A-34 illustrates the occupancy profile used in calculating the utility loads of each office building.

High-Rise Apartment Facility Description

The CBD contains four high-rise apartment buildings offering residents another form of living accommodations. The data on one such building are listed in table A-21. Each building has 32 floors, 21 of which contain apartment units, 10 units on each floor, for a total of 210 units/building. Figure A-35 illustrates the site and floor plan of one building.

The high-rise apartment building design was based on the center corridor concept, which is well suited to such a structure. A variety of individual apartment layouts was provided. The plan for the building reflects the high-density ratio common to high-rise apartments. Structural efficiency, privacy, elevator core location, and the parking ratio were important design and arrangement considerations.

The structural design complies with UBC classification H standards (high-rise residential). Figure A-36 depicts the occupancy profile for one high-rise apartment building. This profile was used in calculating utility loads for each of these buildings.

Community College Facility Description

The community college is sized to serve the adult education needs of a satellite or freestanding community of approximately 100 000 based on statistical information from Columbia, Maryland, concerning existing facilities and their growth projections. The college is designed with a linear core concept to facilitate expansion and to provide a central space for community interaction.

The community college and other school buildings in the community are designed to be compatible with the construction school design systems previously discussed. Future expansion was a prime concern in the facility design. Also, adequate shop and laboratory facilities for technical education programs were provided.

Table A-22 lists the building usage size, the vertical dimensions, and the construction description. The building adheres to UBC classification C-1 standards. The floor plan of the model college is shown in figure A-37. Figure A-38 illustrates the occupancy profile of the college used in calculating utility loads.

Inn and Hotel Complex Facility Description

The inn and hotel complex (fig. A-39) is sized to provide adequate guest accommodations for a satellite or freestanding community of approximately 100 000 people based on the planning program for Columbia, Maryland. The design provides definite market appeal; e.g., the rooms have private balconies oriented to a desirable view. Adequate convention, restaurant, bar, recreational, and laundry facilities are provided. Accessibility to major roadways, sufficient parking, and good vehicular circulation were of prime concern in the design. An efficient structural system and a core facility are desirable for high-rise construction. The overall construction of the complex enables the phasing of construction with market demand.

The construction of the complex is designed to be built in two phases paralleling the growth of the town. Table A-23 lists the descriptive data on the various elements of the complex for both phases. The site plan (fig. A-40)

shows the layout of the complex and the phasing of the various elements. Phase I includes a 75-room 3-story motor inn (see fig. A-41 for a similar floor plan), a 200-room high-rise hotel (fig. A-42), and support facilities. In phase II, the construction plan includes another 75-room 3-story motor inn, 2 more 200-room high-rise hotel towers (with restaurants), and support facilities. A small convention center with two banquet rooms and a large freestanding restaurant are also included in phase II.

All buildings within the inn and hotel complex comply with UBC classification H standards. Occupancy profiles representing one phase of the low-rise inn (fig. A-43) and one high-rise hotel tower (fig. A-44) were used to calculate utility loads. These profiles include the restaurant and banquet rooms.

Community Hospital Facility Description

The basic capacity of a community hospital is from 150 to 450 beds. A 384-bed capacity was selected for this study because this size will provide for a full range of medical services needed for a community of approximately 100 000, and because many hospitals originally planned in the 150- to 200-bed range are expanded over the years to 400 beds.

Because circulation and separation of various activities are prime generators in the functioning and efficiency of a hospital, they affect its design and arrangement. The nurses' station on a floor is a prime generator of form and is directly related to circulation. Mechanical systems arrangement, accessibility, and adaptability are important design considerations. Also, future expansion is an essential criterion for any hospital.

The model hospital complies with UBC classification D-2 standards. Building usage size, vertical dimensions, and a description of the building construction are listed in table A-24. The floor plan and site plan of the hospital are depicted in figure A-45. The dotted lines illustrate the possible expansion of the hospital. Figure A-46 illustrates the occupancy profile used in calculating utility loads.

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A-2. Residential Energy Consumption, Single-Family Housing. Rep. no. HUD-HAI-2, Hittman Associates, Inc., 1972.

A-3. Uniform Building Code. Internat. Conf. Build. Officials (Whittier, Calif.), 1970.

A-4. Residential Energy Consumption, Multi-Family Housing Data Acquisition. Rep. no. HUD-HAI-3, Hittman Associates, Inc., 1972.

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TABLE A-1.- SUMMARY OF DATA FOR AMERICAN SATELLITE NEW TOWNS

New satellite community	Location	Climate, deg-day	Projected population	Area, ha (acre)	Dwelling units, no.	Population, no./ha (no./acre)	Dwelling units, no./ha (no./acre)	Plan	Development schedule, yr
Woodlands	Tex.	1396	150 000	6854.2 (16 937)	49 160	21.88 (8.85)	7.16 (2.90)	Grid	20
Columbia	Md.	4224	110 000	5665.6 (14 000)	30 000	19.39 (7.85)	5.29 (2.14)	Radial	19
Reston	Va.	4224	75 000	2994.7 (7 400)	26 000	25.02 (10.13)	8.67 (3.51)	Radial	- -
Gananda	N.Y.	4871	110 000	4249.2 (10 500)	22 500	25.89 (10.48)	5.29 (2.14)	Grid	- -
Flower Mound	Tex.	2363	64 141	2491.2 (6 156)	18 326	25.74 (10.42)	7.34 (2.97)	Grid	17
Shenandoah	Ga.	2961	70 000	2913.7 (7 200)	23 000	24.01 (9.72)	7.90 (3.20)	Radial	- -
San Antonio	Tex.	1396	88 000	3726.7 (9 209)	28 200	23.61 (9.56)	7.71 (3.12)	Radial	30
St. Charles	Md.	4224	75 000	3197.0 (7 900)	25 855	23.44 (9.49)	8.10 (3.28)	Grid	- -
Riverton	N.Y.	4871	27 000	944.9 (2 335)	8 010	28.56 (11.56)	8.50 (3.44)	Radial	15
Park Forest South	Ill.	5882	110 000	3355.2 (8 291)	35 000	32.78 (13.27)	10.45 (4.23)	Radial	- -
Maumelle	Ark.	3860	45 000	2144.8 (5 300)	14 349	20.97 (8.49)	6.69 (2.71)	Radial	20
Jonathan	Minn.	8382	50 000	2428.1 (6 000)	15 500	20.58 (8.33)	6.37 (2.58)	Radial	20
Lysander	N. Mex.	4871	18 000	1080.5 (2 670)	5 000	16.65 (6.74)	4.62 (1.87)	Radial	- -
Harbison	Md.	4871	20 000	809.4 (2 000)	6 000	24.70 (10.00)	7.41 (3.00)	Grid	- -

TABLE A-2.- SUMMARY OF AVERAGE DATA FOR

14 NEW SATELLITE TOWNS

Category	Value
Projected population	71 700
Area, ha (acre)	2970.4 (7340)
Dwelling units, no.	21 600
Population, no./ha (no./acre)	24.14 (9.77)
Dwelling units, no./ha (no./acre)	7.27 (2.94)
Development schedule, yr	20

TABLE A-3.- NEW-TOWN SELECTION CRITERIA COMPLIANCE

New town	Average climate	Design state of the art	Size	Projected population	Projected dwelling units	Population density	Dwelling-unit density	Building mix	Phasing schedule consistency	Total
Assigned values for study importance										
- -	10	7	4	4	4	7	7	7	7	- -
Assigned values multiplied by compliance judgment factor[1]										
Columbia	30	14	8	8	12	14	7	21	21	135
Reston	30	14	12	12	12	14	14	7	7	122
St. Charles	30	14	12	4	4	21	14	14	7	120
Park Forest South	30	14	8	12	4	7	7	14	7	103

[1]Compliance judgment factors are high (3), medium (2), and low (1).

TABLE A-4.- FORECASTED LOCAL RETAIL POTENTIAL FOR ONE VILLAGE CENTER

Parameter	Value
Number of families in service area	5000
Estimated average income per family	$15 000
Aggregate income	$75 000 000
Convenience-goods expenditures (as percent of aggregate income)	20
Convenience-goods expenditures	$15 000 000
Capture rate, percent	50
Convenience-goods sales potential	$7 500 000
Required sales per year, $/m² ($/ft²)	1076 (100)
Supportable convenience-goods retail space, m² (ft²)	6967 (75 000)

TABLE A-5.- FORECASTED RETAIL COMMERCIAL POTENTIAL FOR THE CBD

Parameter	Value
Number of families	83 000
Estimated average income per family . . .	$15 000
Aggregate income	$1 245 000 000
Convenience-goods expenditures (as a percent of aggregate income).	20
Convenience-goods expenditures	$249 000 000
New-town capture rate, percent	50
Convenience-goods sales potential	$124 500 000
Required sales per year, $/m² ($/ft²) . .	1076 (100)
Supportable convenience-goods retail space, m² (ft²)	115 664 (1 245 000)

TABLE A-6.- CONCEPTUAL NEW TOWN

Parameter	Value
Target population	110 000
Development period, yr	20
Villages, no.	7
Neighborhoods, no.	21
Gross density, no./ha (no./acre) . . .	22.2 (9)
Institutional facilities:	
Elementary schools, no.	21
Secondary schools, no.	14
Community colleges, no.	1
Hospitals, no.	1
Land use:	
Residential, ha (acre)	2819.9 (6968)
Industrial, ha (acre)	463.0 (1144)
Commercial/office, ha (acre)	481.1 (1189)
Permanent open space:	
Unstructured/roads, ha (acre) . . .	434.2 (1073)
Parks, ha (acre)	420.5 (1039)
Golf courses, ha (acre).	121.4 (300)
Lakes, ha (acre)	115.3 (285)
Total open space, ha (acre)[1] . .	1091.4 (2697)
Total area, ha (acre)	4855.4 (11 998)

[1]Population density: 9.91 ha/1000 (24.5 acres/1000).

TABLE A-7.- THREE-YEAR NEIGHBORHOODS

Facility	Quantity	Year activated		
		1	2	3
Garden apartments	162	X	X	
Townhouses	108	X	X	X
Single-family detached housing	238	X	X	X
Elementary schools	3	X		

TABLE A-8.- THREE-YEAR VILLAGE CENTER

Facility	Quantity	Year activated		
		1	2	3
Shopping center	1	X		
High-rise apartments	2	X	X	X
Office building	1		X	X
Middle school	1		X	
Recreation area	1			X
High school	1			X

TABLE A-9.- FOUR-YEAR NEIGHBORHOODS

Facility	Quantity	Year activated			
		1	2	3	4
Garden apartments	162	X	X		
Single-family detached housing	178	X	X	X	X
Townhouses	108		X	X	X
Elementary schools	3	X			

TABLE A-10.- FOUR-YEAR VILLAGE CENTER

Facility	Quantity	Year activated			
		1	2	3	4
Shopping center	1	X			
Office building	1		X		X
High-rise apartments	3	X	X	X	X
Recreation center	1			X	
Middle school	1			X	
High school	1				X

TABLE A-11.- CENTRAL BUSINESS DISTRICT

Facility	Phase	Year activated																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Office building	- -		X		X	X			X	X	X						X		X
Regional shopping mall	I, II, and III				X					X					X				
Inn and hotel complex	I and II			X					X										
Community college	I and II					X						X							
Hospital	I and II						X						X						
High-rise apartment	- -			X					X		X								

TABLE A-12.- SINGLE-FAMILY DWELLING DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Living room	20.07 (216)
Dining room	13.94 (150)
Kitchen	10.22 (110)
Family room	17.37 (187)
Bath and hall	8.08 (87)
Total ground floor	69.68 (750)
Master bedroom	18.21 (196)
Bedroom 1	9.29 (100)
Bedroom 2	11.43 (123)
Bedroom 3	16.72 (180)
Bath and hall	14.03 (151)
Total second floor	69.68 (750)
Total comfort-conditioned area	139.36 (1500)
Total enclosed area	139.36 (1500)

(b) Dimensions and construction

Vertical dimensions:
- Floor-to-floor height, m (ft) 2.74 (9)
- Floor-to-ceiling height, m (ft) 2.44 (8)

Building construction:
- Type of wall (fig. A-11) . . . . No. 3
- Type of roof (fig. A-12) . . . . No. 2
- Type of glazing . . . . Single pane
- Percentage of glass in exterior walls 13

TABLE A-13.- TOWNHOUSE DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Family room	11.52 (124)
Kitchen	8.73 (94)
Living room	22.30 (240)
Bath and hall	17.84 (192)
Total ground floor	60.39 (650)
Master bedroom	20.07 (216)
Bedroom 1	8.92 (96)
Bedroom 2	13.84 (149)
Bath and hall	17.56 (189)
Total second floor	60.39 (650)
Total comfort-conditioned area	120.78 (1300)
Total enclosed area	120.78 (1300)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	3.05 (10)
Floor-to-ceiling height, m (ft)	2.74 (9)
Building construction:	
Type of wall (fig. A-11)	No. 1
Type of roof (fig. A-12)	No. 2
Type of glazing	Single pane
Percentage of glass in exterior walls	14

TABLE A-14.- ELEMENTARY SCHOOL DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Classrooms	954.67 (10 276)
Library	280.29 (3 017)
Administration	167.23 (1 800)
Cafetorium	334.45 (3 600)
Kitchen	111.48 (1 200)
Restrooms	78.97 (850)
Halls	141.68 (1 525)
Total comfort-conditioned area	2068.77 (22 268)
Total enclosed area	2068.77 (22 268)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	3.66 (12)
Floor-to-ceiling height, m (ft)	2.74 (9)
Building construction:	
Type of wall (fig. A-11)	No. 5
Type of roof (fig. A-12)	No. 1
Type of glazing	Single pane
Percentage of glass in exterior walls	21.5

TABLE A-15.- VILLAGE CENTER COMMERCIAL FACILITY DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Supermarket	3010.06 (32 400)
Retail commercial	1003.35 (10 800)
Office lease space	1003.35 (10 800)
Mall	543.48 (5 850)
Total comfort-conditioned area	5560.24 (59 850)
Total enclosed area	5560.24 (59 850)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	
Offices and stores	3.35 (11)
Supermarket	5.49 (18)
Mall	4.57 (15)
Floor-to-ceiling height, m (ft)	
Offices and stores	2.74 (9)
Supermarket	4.88 (16)
Building construction:	
Type of wall (fig. A-11)	No. 1
Type of roof (fig. A-12)	No. 1
Type of glazing	Single-pane glass skylight
Percentage of glass in exterior walls . .	51

TABLE A-16.- MEDIUM-RISE APARTMENT DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Service/entry floor	1 217.03 (13 100)
Typical apartment floor (multiplied by number of floors (10))	12 170.29 (131 000)
Total comfort-conditioned area	13 387.32 (144 100)
Total enclosed area	13 387.32 (144 100)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	
Service/entry floor	3.66 (12)
Typical apartment floor	2.90 (9.5)
Floor-to-ceiling height, m (ft)	
Service/entry floor	3.51 (11.5)
Apartments	2.74 (9)
Corridors	2.29 (7.5)
Building construction:	
Type of wall (fig. A-11)	No. 5
Type of roof (fig. A-12)	No. 1
Type of glazing	Double pane
Percentage of glass in exterior walls . . .	68

TABLE A-17.- MIDDLE SCHOOL DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Classrooms	2956.64 (31 825)
Music	334.45 (3 600)
Library	362.32 (3 900)
Offices	195.10 (2 100)
Administration	445.93 (4 800)
Kitchen	195.10 (2 100)
Cafeteria	418.06 (4 500)
Restrooms	148.64 (1 600)
Halls	316.33 (3 405)
Total comfort-conditioned area	5372.57 (57 830)
Gymnasium	668.90 (7 200)
Mechanical room	334.45 (3 600)
Total enclosed area	6375.92 (68 630)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	3.66 (12)
Floor-to-ceiling height, m (ft)	2.74 (9)
Building construction:	
Type of wall (fig. A-11)	No. 5
Type of roof (fig. A-12)	No. 1
Type of glazing	Single pane
Percentage of glass in exterior walls	21.5

TABLE A-18.- HIGH SCHOOL DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Administration	418.06 (4 500)
Auditorium	852.39 (9 175)
Classrooms	2545.54 (27 400)
Dressing area	668.90 (7 200)
Cafeteria	455.22 (4 900)
Kitchen	120.77 (1 300)
Library	334.45 (3 600)
Music	334.45 (3 600)
Restrooms	148.64 (1 600)
Laboratories	668.90 (7 200)
Office	111.48 (1 200)
Shops	334.45 (3 600)
Halls	366.97 (3 950)
Total comfort-conditioned area	7360.22 (79 225)
Gymnasium	668.90 (7 200)
Mechanical room	334.45 (3 600)
Total enclosed area	8363.57 (90 025)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	3.66 (12)
Floor-to-ceiling height, m (ft)	2.74 (9)
Building construction:	
Type of wall (fig. A-11)	No. 5
Type of roof (fig. A-12)	No. 1
Type of glazing	Single pane
Percentage of glass in exterior walls . . .	21.5

TABLE A-19.- REGIONAL SHOPPING CENTER DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Major department stores (5)	97 548.15 (1 050 000)
Commercial shops	55 741.80 (600 000)
Restaurants	11 148.36 (120 000)
Pharmacies	8 361.27 (90 000)
Offices	8 361.27 (90 000)
Malls (3)	18 208.99 (196 000)
Total enclosed area	199 369.84 (2 146 000)
Total comfort-conditioned area	199 369.84 (2 146 000)

(b) Dimensions and construction

Vertical Dimensions:	
Floor-to-floor height, m (ft)	
Major department stores	5.18 (17)
Commercial shops	4.57 (15)
Restaurants	4.57 (15)
Pharmacies	4.57 (15)
Offices	4.57 (15)
Malls	9.14 (30)
Floor-to-ceiling height, m (ft)	
Major department stores	4.27 (14)
Commercial shops	3.66 (12)
Restautrants	3.66 (12)
Offices	2.74 (9)
Malls	9.14 (30)
Building construction:	
Type of wall (fig. A-11)	No. 5
Type of roof (fig. A-12)	No. 1
Type of glazing	Single pane
Percentage of glass in exterior walls	2

TABLE A-20.- HIGH-RISE OFFICE DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Lease space	18 506.28 (199 200)
Mechanical/halls/tower	3 790.44 (40 800)
Total enclosed area/tower	22 296.72 (240 000)
Total comfort-conditioned area	22 296.72 (240 000)

(b) Dimensions and construction

Vertical dimension:
- Floor-to-floor height, m (ft) 3.66 (12)
- Floor-to-ceiling height, m (ft) 2.74 (9)

Building construction:
- Type of wall (fig. A-11) . . . . No. 5
- Type of roof (fig. A-12) . . . . No. 1
- Type of glazing . . . . Double pane
- Percentage of glass in exterior walls . . . 16

TABLE A-21.- HIGH-RISE APARTMENT DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Service/entry floor	1 217.03 (13 100)
Typical apartment floor (multiplied by number of floors (21))	25 557.62 (275 100)
Total enclosed area	26 774.65 (288 200)
Total comfort-conditioned area	26 774.65 (288 200)

(b) Dimensions and construction

Vertical dimensions:
- Floor-to-floor height, m (ft)
  - Service/entry floor 3.66 (12)
  - Typical apartment floor 2.90 (9.5)
- Floor-to-ceiling height, m (ft)
  - Service/entry floor 3.51 (11.5)
  - Apartments 2.74 (9)
  - Corridors 2.29 (7.5)

Building construction:
- Type of wall (fig. A-11) . . . . No. 5
- Type of roof (fig. A-12) . . . . No. 1
- Type of glazing . . . . Double pane
- Percentage of glass in exterior walls . . . 68

TABLE A-22.- COMMUNITY COLLEGE DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Classrooms	2243.61 (24 150)
Offices	277.78 (2 990)
Administration	167.23 (1 800)
Library	334.45 (3 600)
Laboratories	1505.03 (16 200)
Restrooms	79.90 (860)
Halls	148.64 (1 600)
Total comfort-conditioned area	4756.64 (51 200)
Shops	1170.58 (12 600)
Mechanical room	58.06 (625)
Total enclosed area	5985.28 (64 425)

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	3.35 (11)
Floor-to-ceiling height, m (ft)	2.59 (8.5)
Building construction:	
Type of wall (fig. A-11)	No. 3
Type of roof (fig. A-12)	No. 1
Type of glazing	Double pane
Percentage of glass in exterior walls . . .	44

TABLE A-23.- INN AND HOTEL COMPLEX DESCRIPTION

(a) Building usage

Unit	Area, m² (ft²)
High-rise hotel (one tower)	
Mechanical	1 216.01 (13 089)
Halls	56.30 (606)
Total basement	1 272.31 (13 695)
Restaurant	408.77 (4 400)
Kitchen	153.20 (1 649)
Lobby	225.94 (2 432)
Office	148.64 (1 600)
Halls	78.60 (846)
Total ground floor	1 015.15 (10 927)
Manager's apartment	148.64 (1 600)
Bar	148.64 (1 600)
Halls	196.95 (2 120)
Total second floor	494.23 (5 320)
Total comfort-conditioned area	2 781.69 (29 942)
Total enclosed area	2 781.69 (29 942)
High-rise hotel (three towers)	
Total comfort-conditioned area	8 345.07 (89 826)
Total enclosed area	8 345.07 (89 826)
Low-rise inn	
Phase I[1]	3 483.86 (37 500)
Phase II[1]	3 483.86 (37 500)
Total comfort-conditioned area	6 967.72 (75 000)
Total enclosed area	6 967.72 (75 000)
Banquet rooms	
Total comfort-conditioned area	613.16 (6 600)
Total enclosed area	613.16 (6 600)
Restaurant	
Total comfort-conditioned area	501.68 (5 400)
Total enclosed area	501.68 (5 400)
Inn and hotel complex	
Total comfort-conditioned area	16 427.63 (176 826)
Total enclosed area	16 427.63 (176 826)

[1]Area multiplied by number of rooms: 46.45 x 75 (500 x 75).

TABLE A-23.- Concluded

(b) Dimensions and construction

Vertical dimensions:	
Floor-to-floor height, m (ft)	
Bedrooms in hotel towers	2.90 (9.5)
Bedrooms in low-rise inn	3.35 (11)
Manager's office and apartment	3.35 (11)
Lobby	6.71 (22)
Banquet rooms	3.35 (11)
Restaurant	3.35 (11)
Floor-to-ceiling height, m (ft)	
Bedrooms in hotel towers	2.74 (9)
Bedrooms in low-rise inn	2.74 (9)
Manager's office and apartment	2.74 (9)
Lobby	6.10 (20)
Banquet rooms	2.74 (9)
Restaurant	2.74 (9)
Building construction:	
Type of wall (fig. A-11)	
High-rise hotel	No. 5
Low-rise inn	No. 4 (rear wall); No. 5 (end and party wall)
Banquet rooms	No. 5
Restaurant	No. 5
Type of roof (entire complex) (fig. A-12)	No. 1
Type of glazing	
High-rise hotel	Double pane
Low-rise inn	Single pane
Banquet rooms	Double pane
Restaurant	Double pane
Percentage of glass in exterior walls	
High-rise hotel	
Ground floor	5.9
Mezzanine	5.9
10 floors of bedrooms	88.2
Low-rise inn	
Banquet rooms	20
Restaurant	60

TABLE A-24.- COMMUNITY HOSPITAL DESCRIPTION

(a) Building usage

Unit	Area, m^2 (ft^2)
Service floor (ground level)	1 393.55 (15 000)
Social floor (main level)	929.03 (10 000)
Typical floor (multiplied by number of floors (12))	7 803.85 (84 000)
Total enclosed area	10 126.43 (109 000)
Total comfort-conditioned area	10 126.43 (109 000)

(b) Dimensions and construction

Vertical dimension (social and service floors):

Floor-to-floor height, m (ft)	4.88 (16)
Floor-to-ceiling height, m (ft)	3.66 (12)

Building construction:

Type of wall (fig. A-11)	No. 5
Type of roof (fig. A-12)	No. 1
Type of glazing	Double pane
Percentage of glass in exterior walls . . .	28

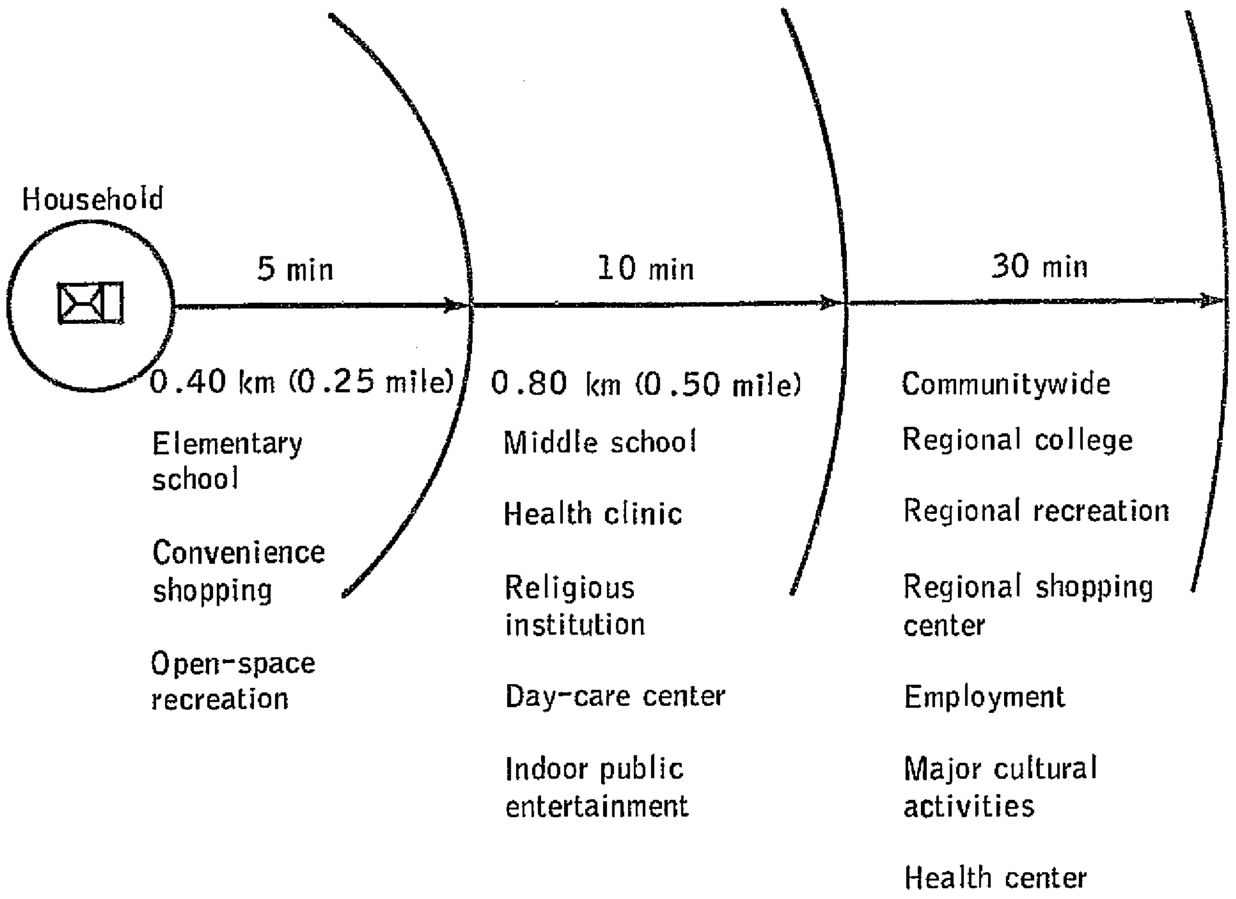

Figure A-1.- Walking distances from households to community activities.

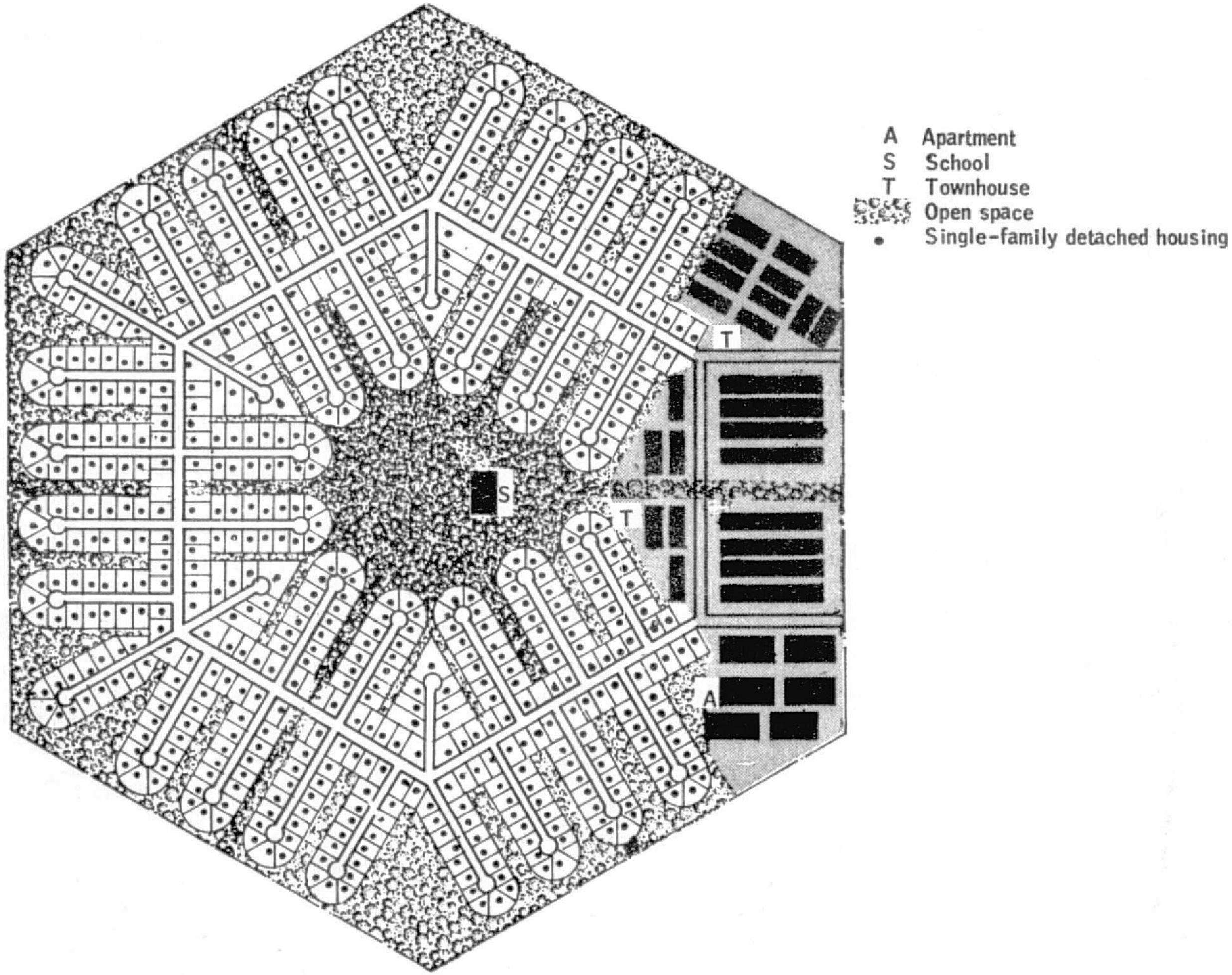

Figure A-2.- Design of the neighborhood.

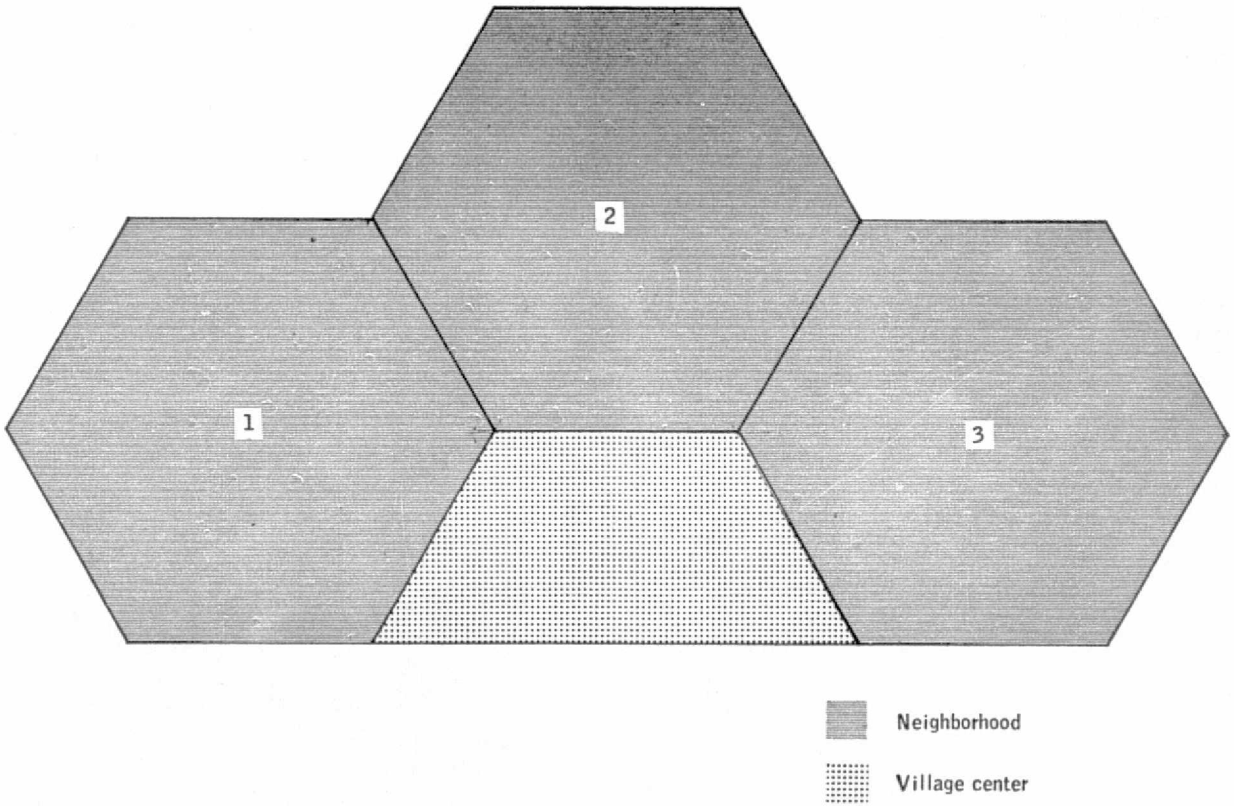

Figure A-3.- The village complex.

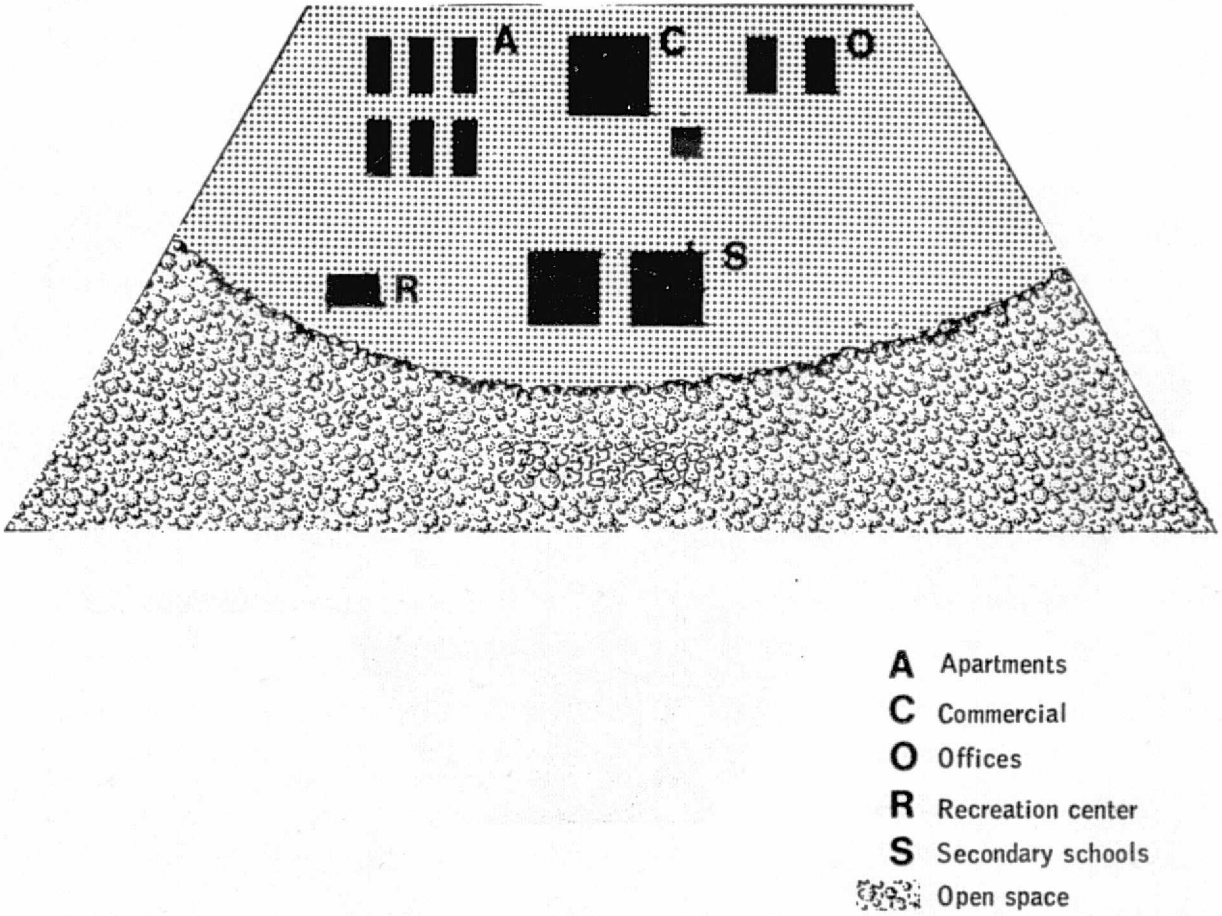

Figure A-4.- The village center.

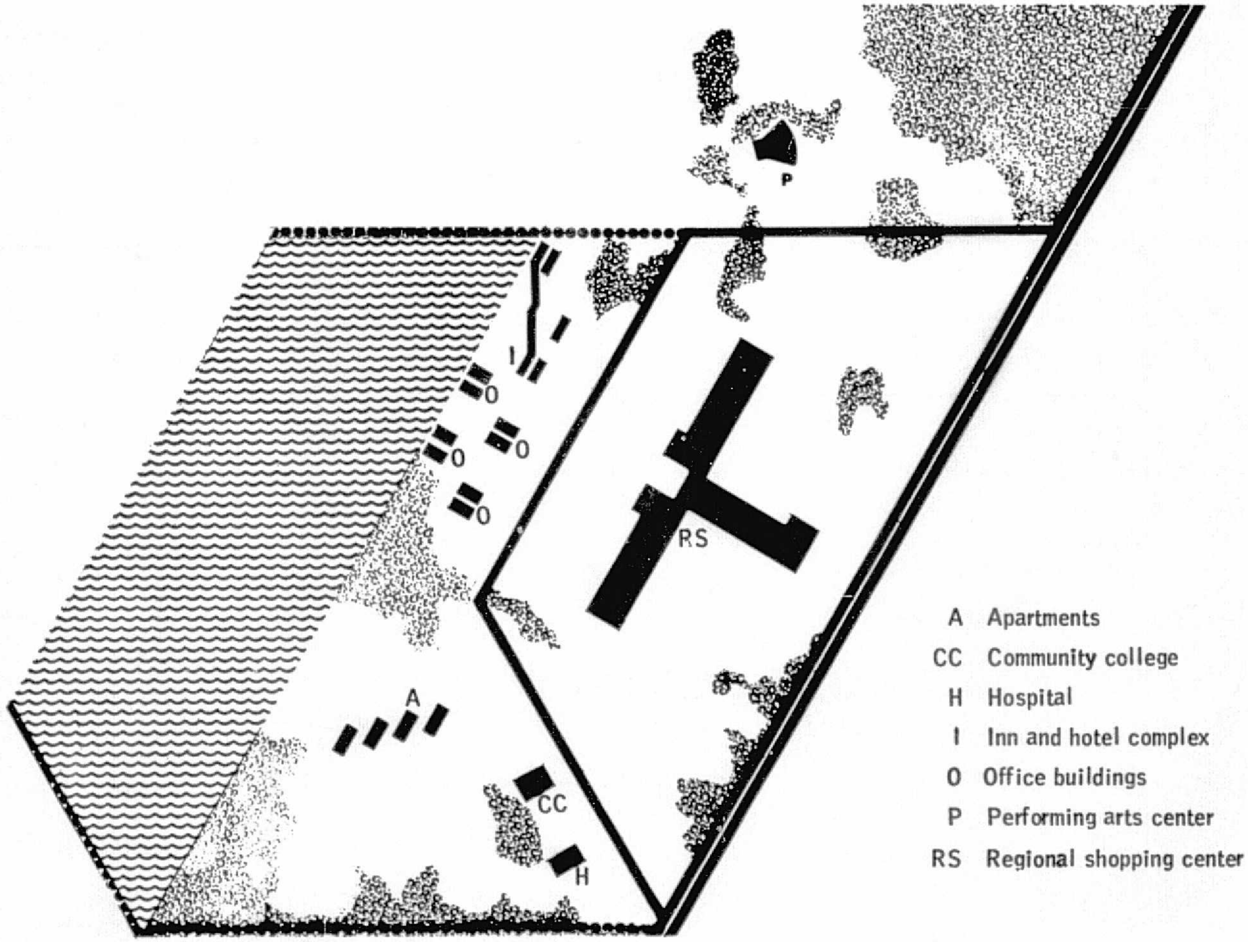

Figure A-5.- The central business district.

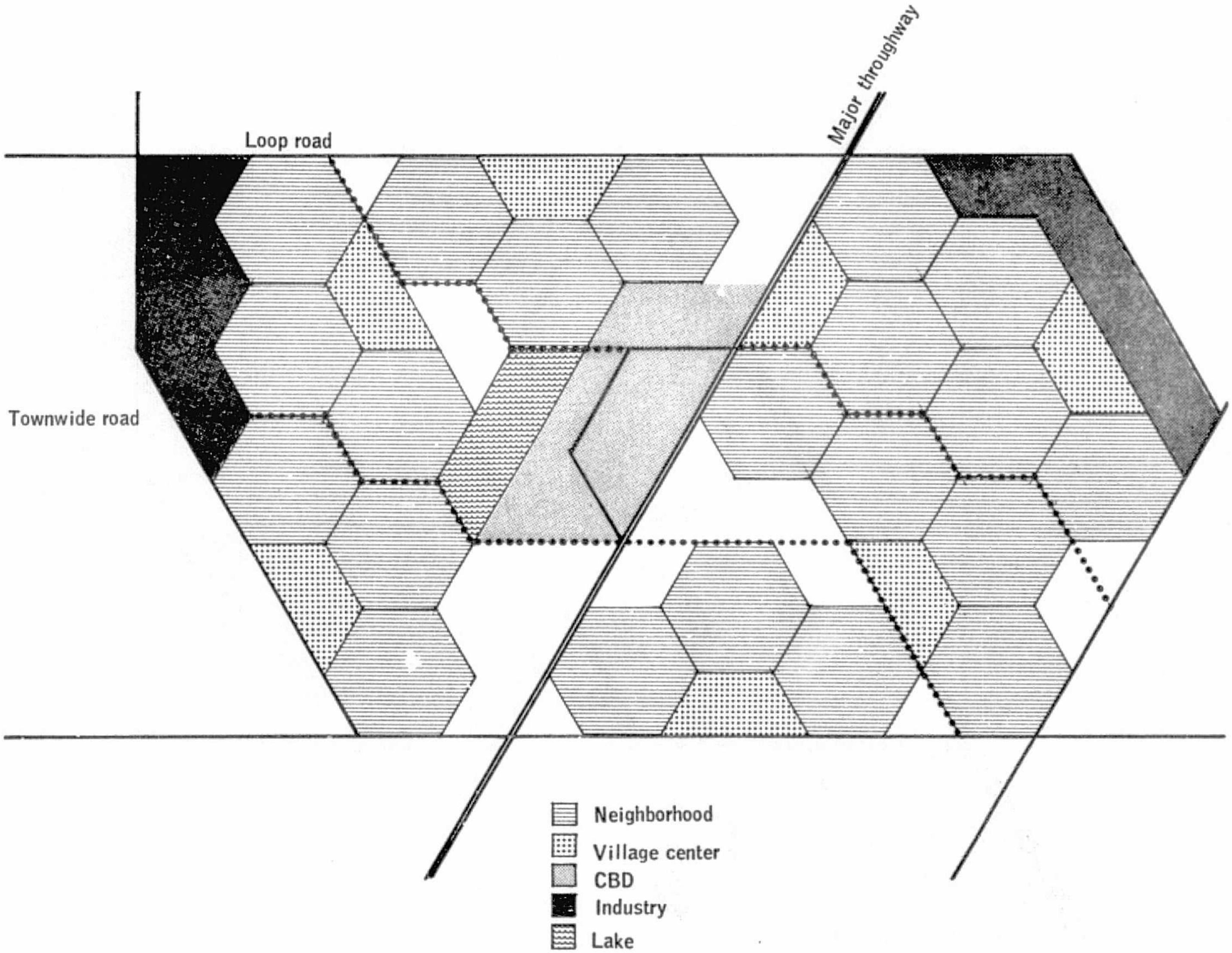

Figure A-6.- The composite new community.

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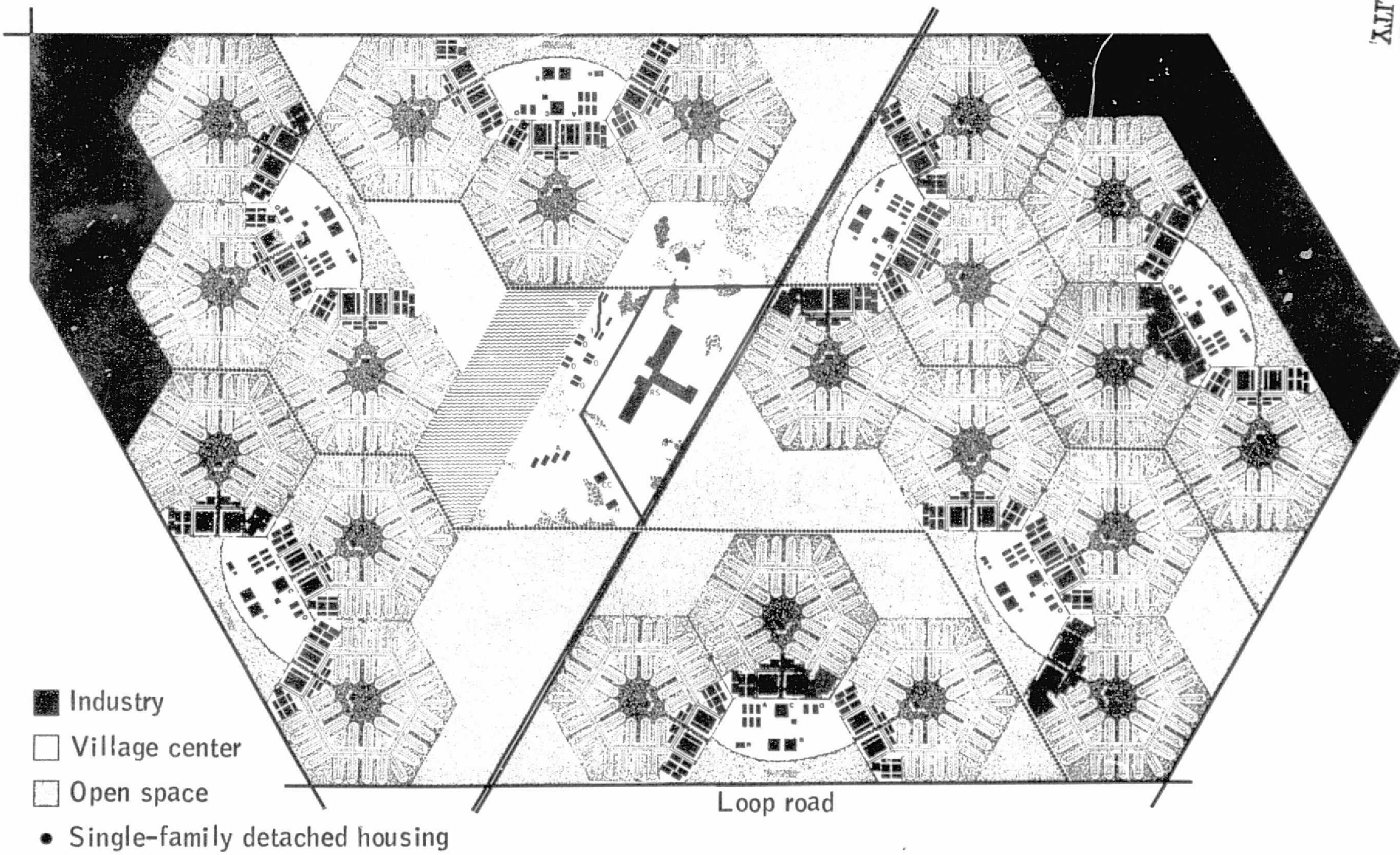


Figure A-7.- Layout of the new community.

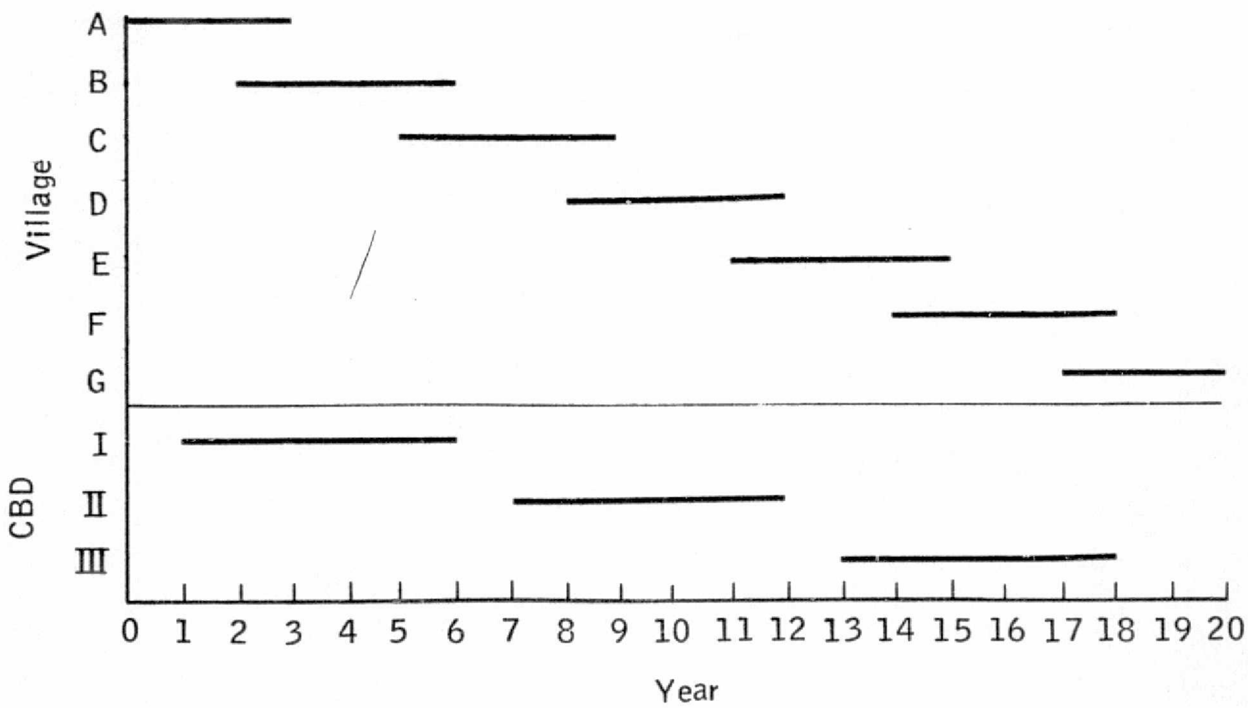


Figure A-8.- Estimated construction schedule for the villages and the three phases of the CBD.

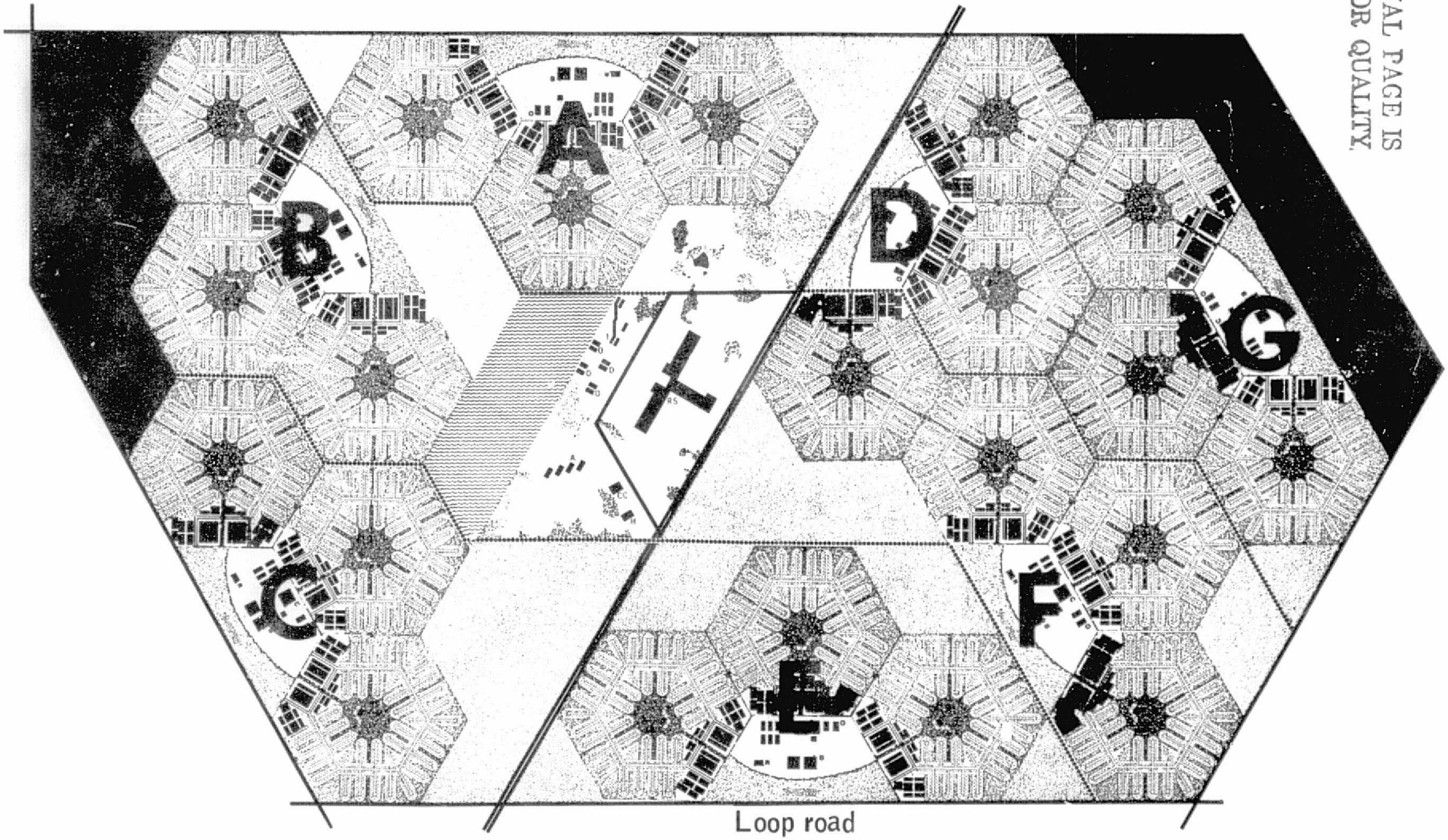


Figure A-9.- Layout showing community phasing scheme.

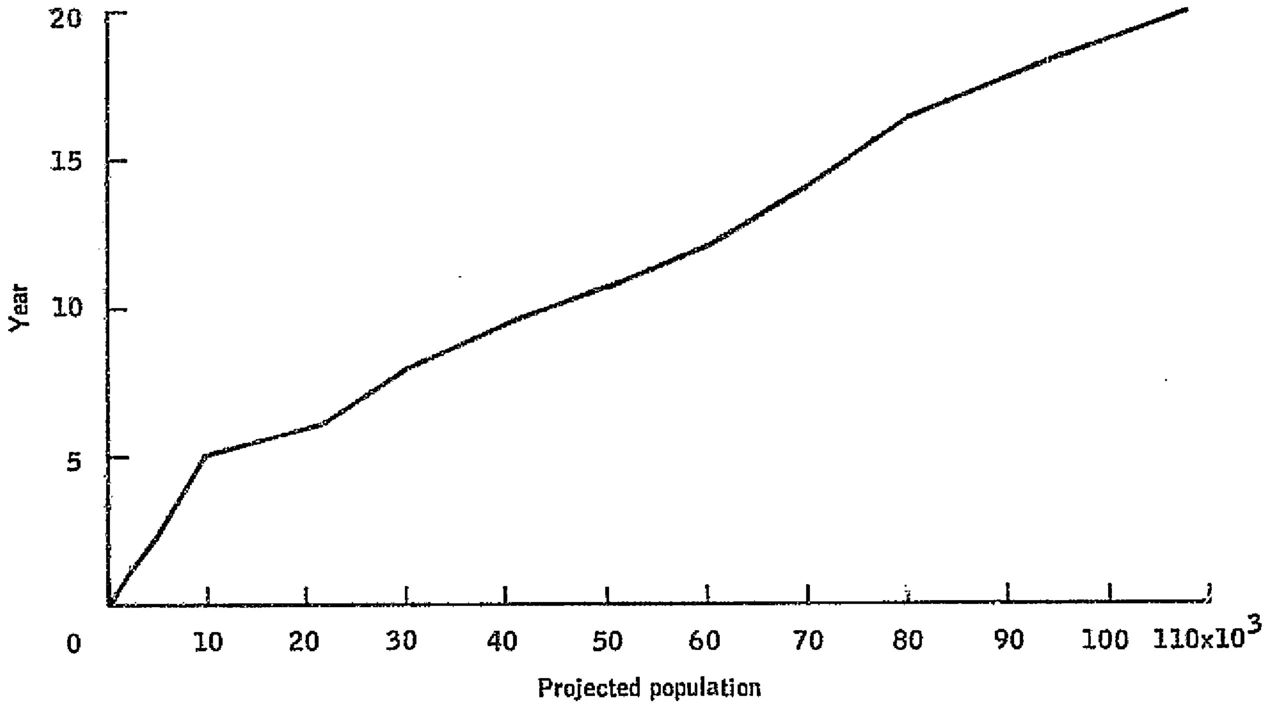


Figure A-10.- Relationship of phasing schedule to projected population growth.

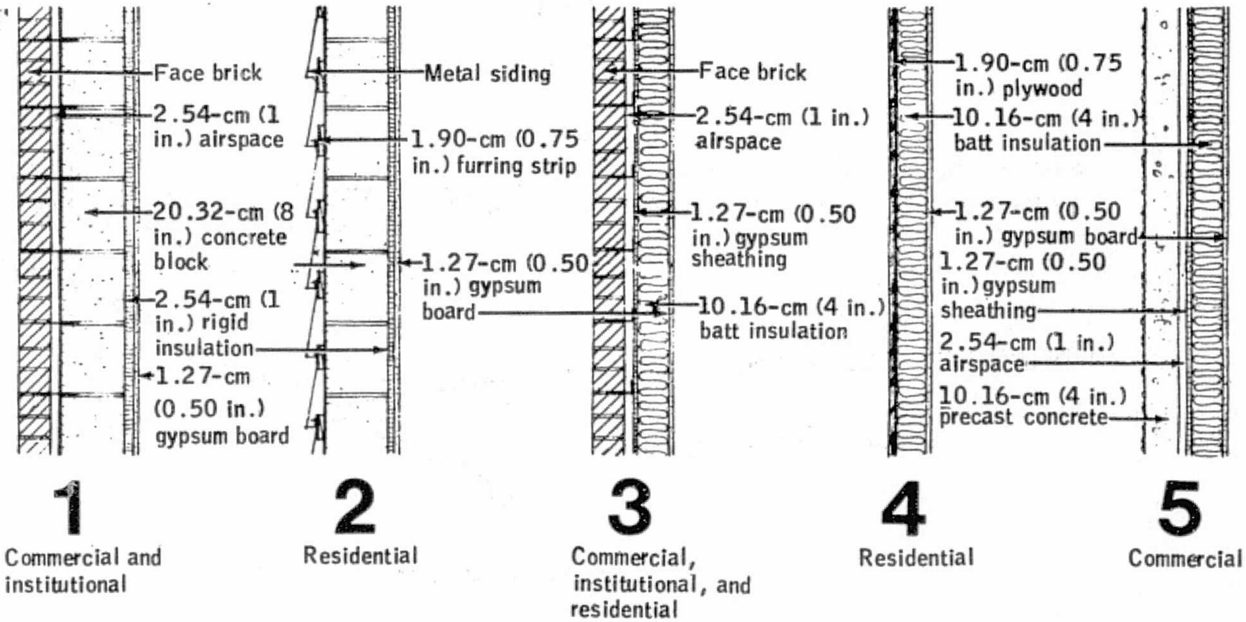


Figure A-11.- Typical wall sections.

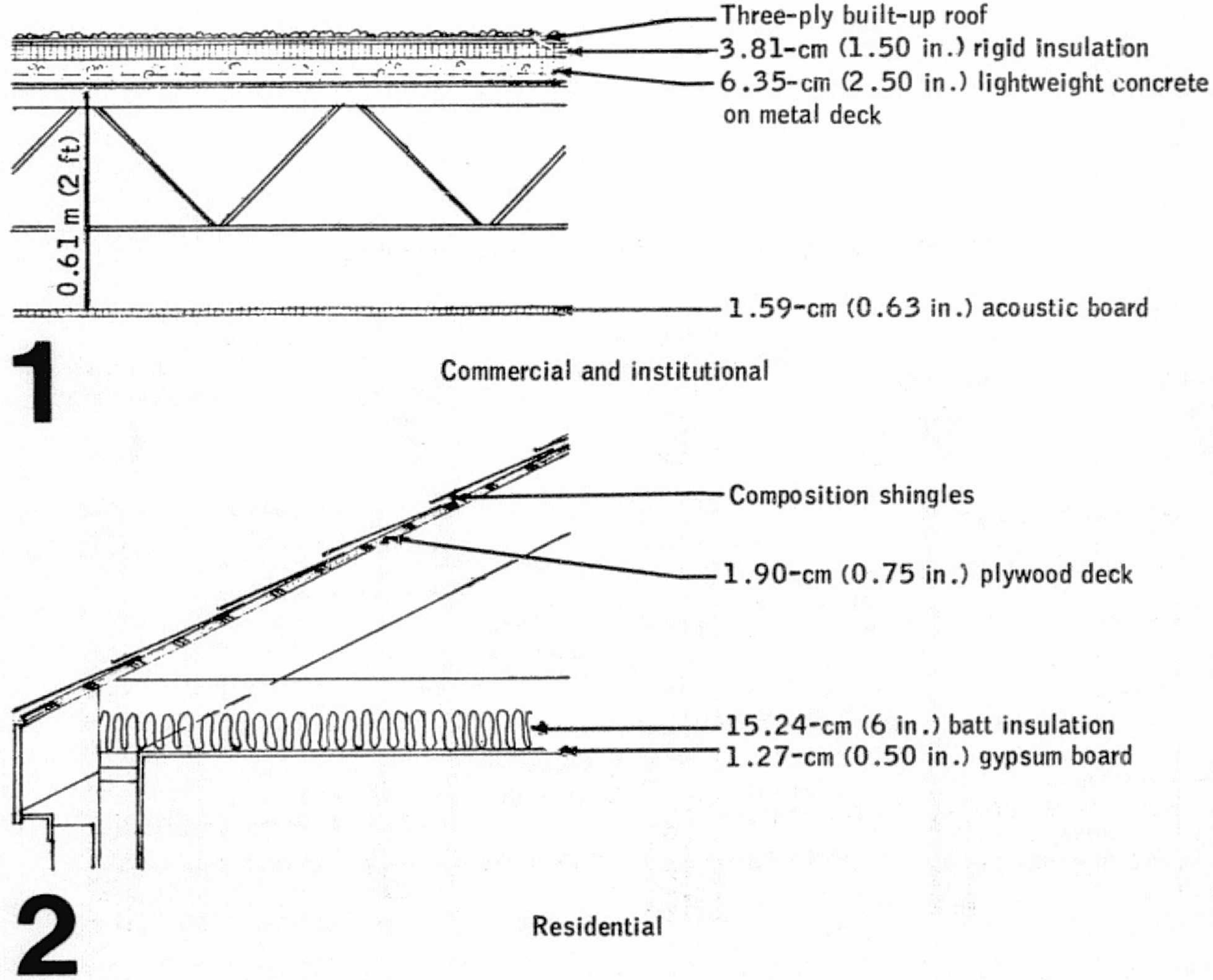


Figure A-12.- Typical roof sections.

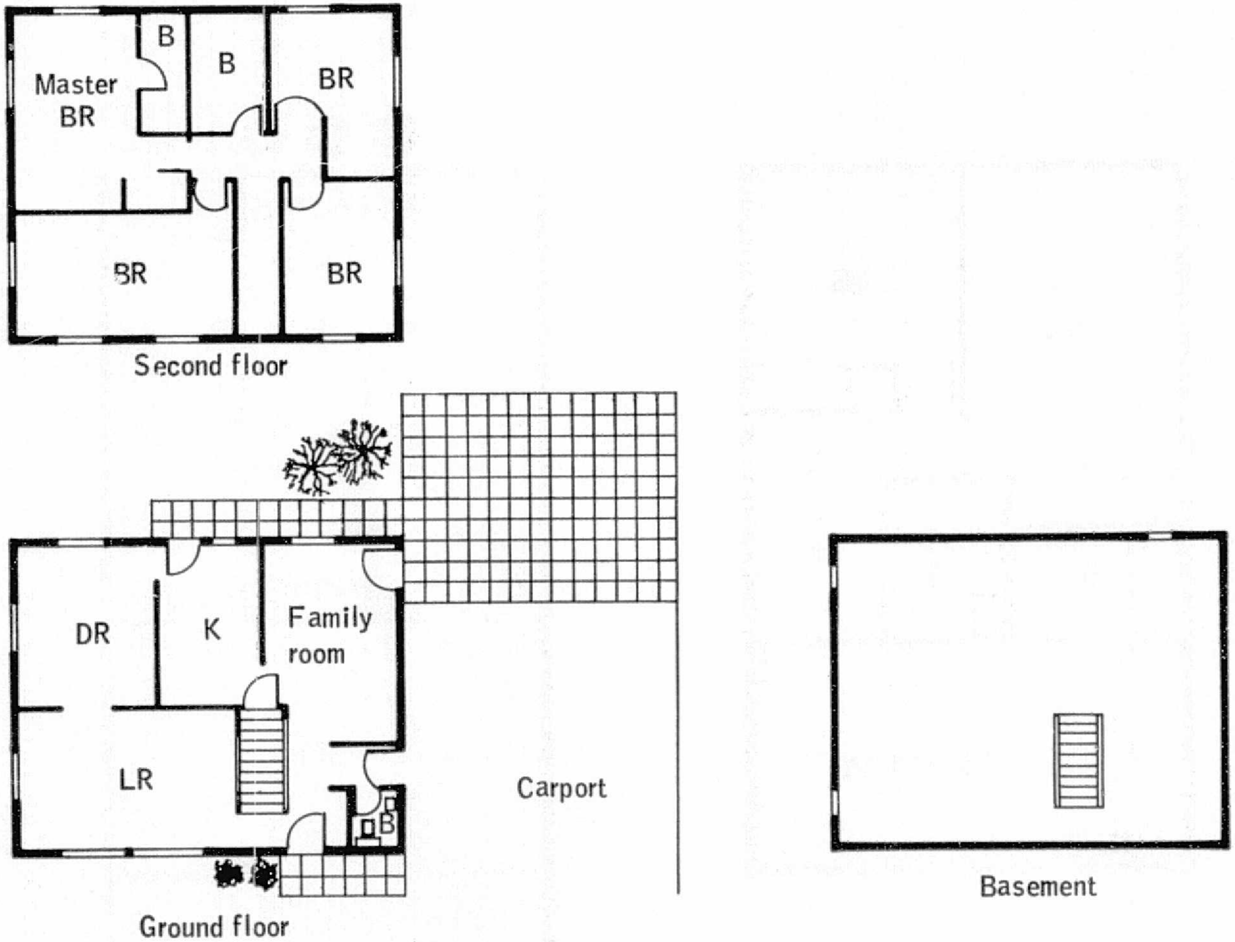
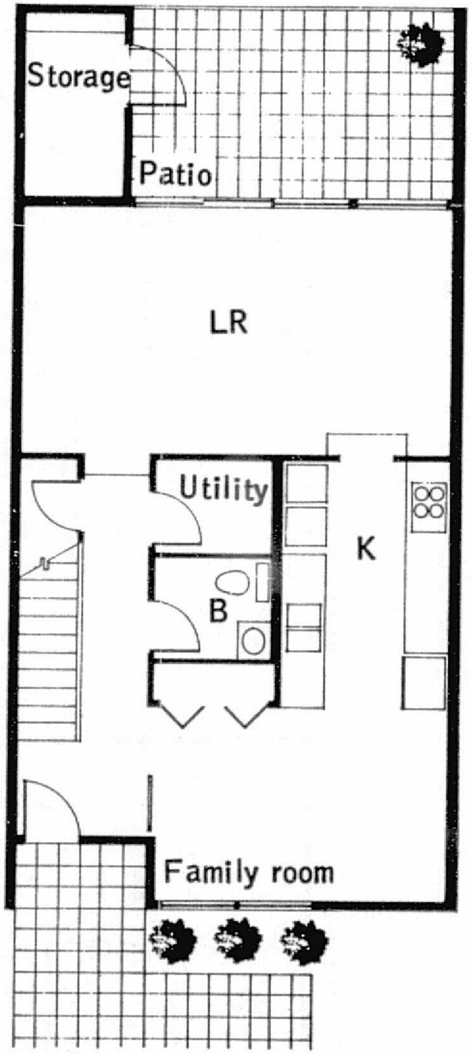
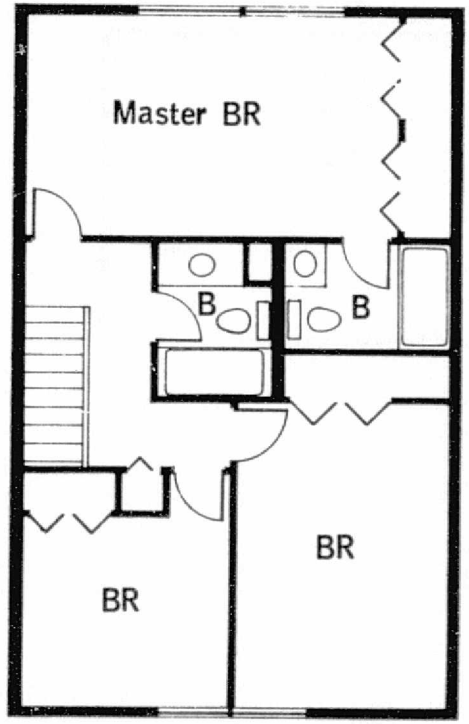


Figure A-13.- Floor plan for single-family model.



Ground floor



Second floor

Figure A-14.- Floor plan for townhouse model.

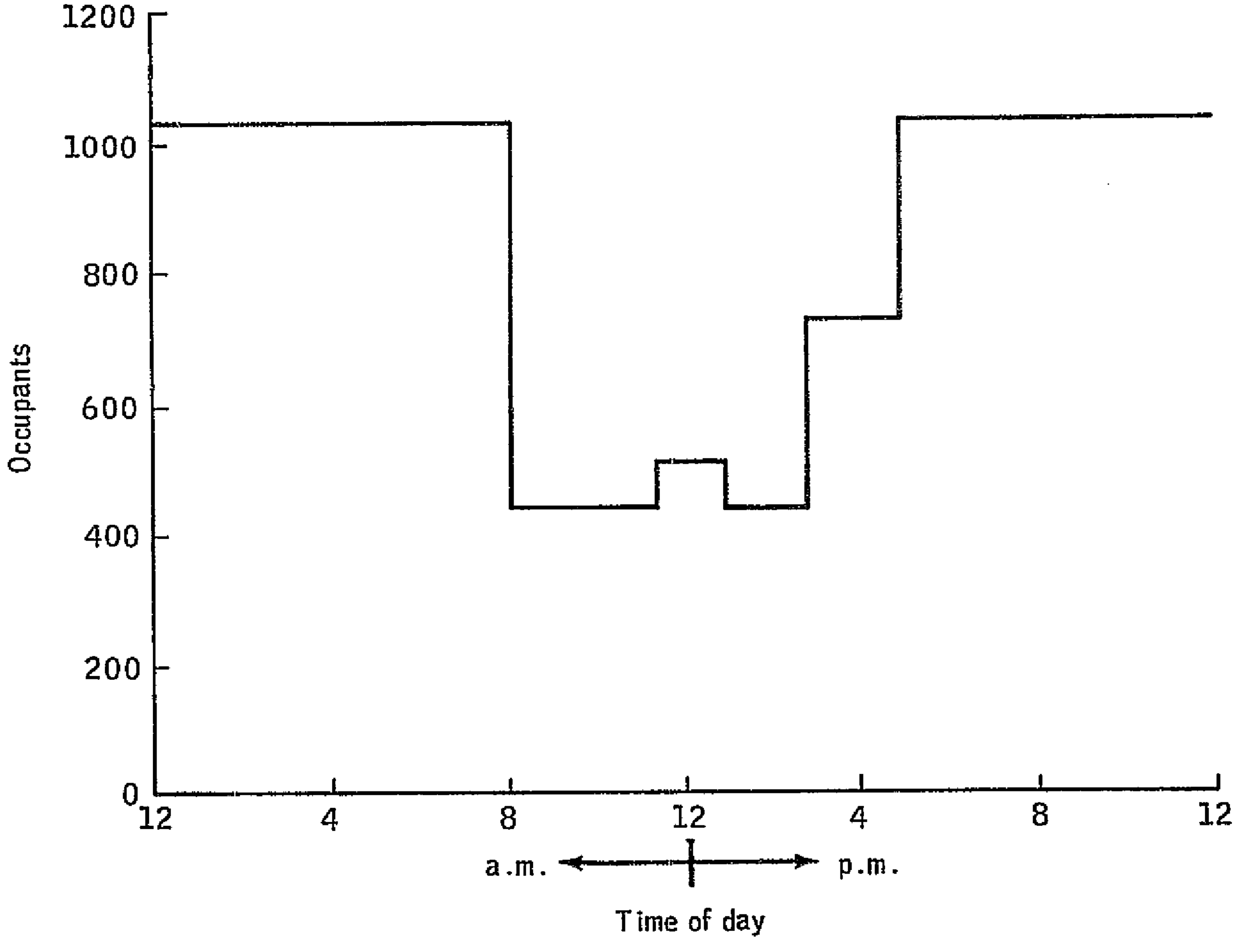


Figure A-15.- Estimated occupancy profile of townhouses.

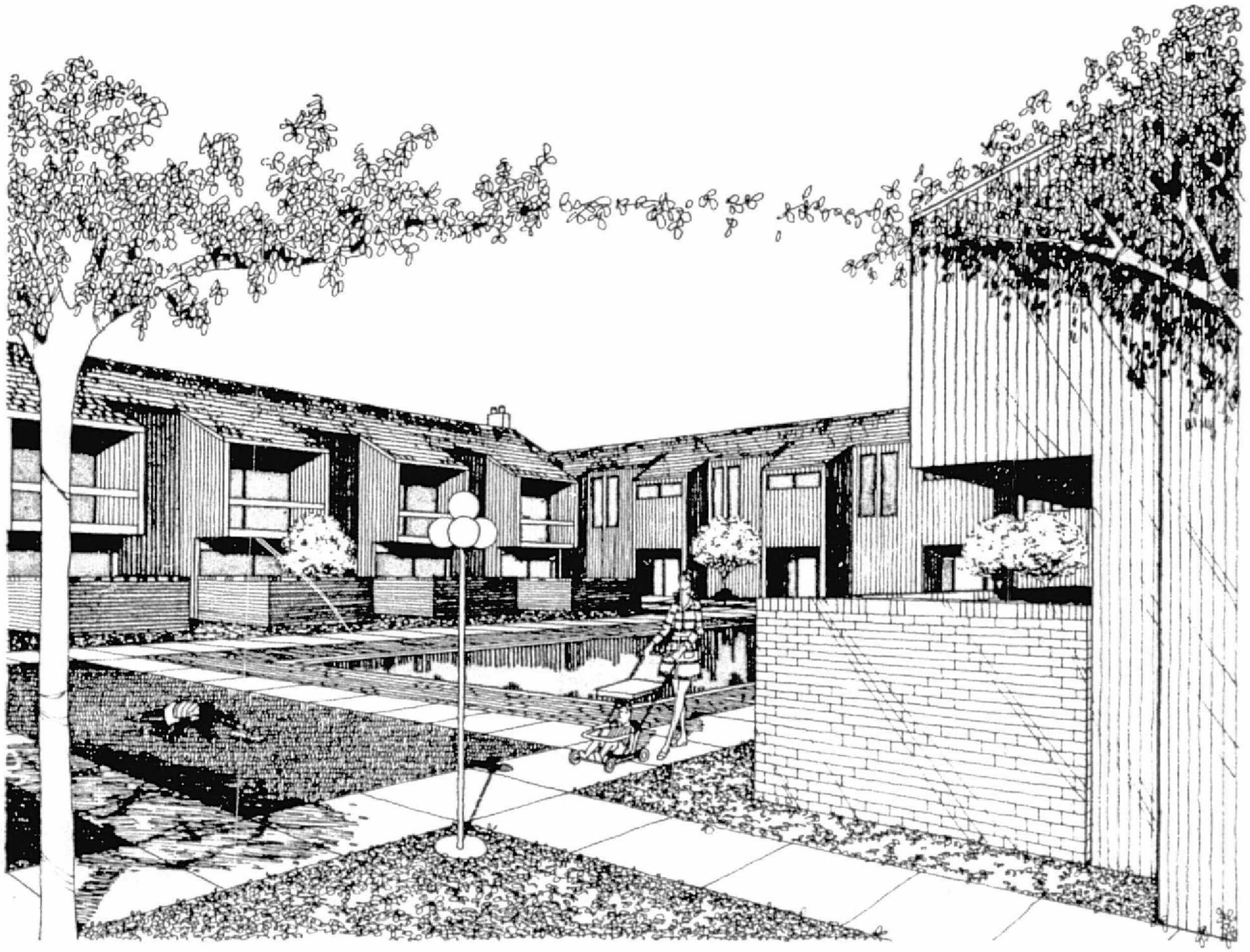


Figure A-16.- Garden apartments.

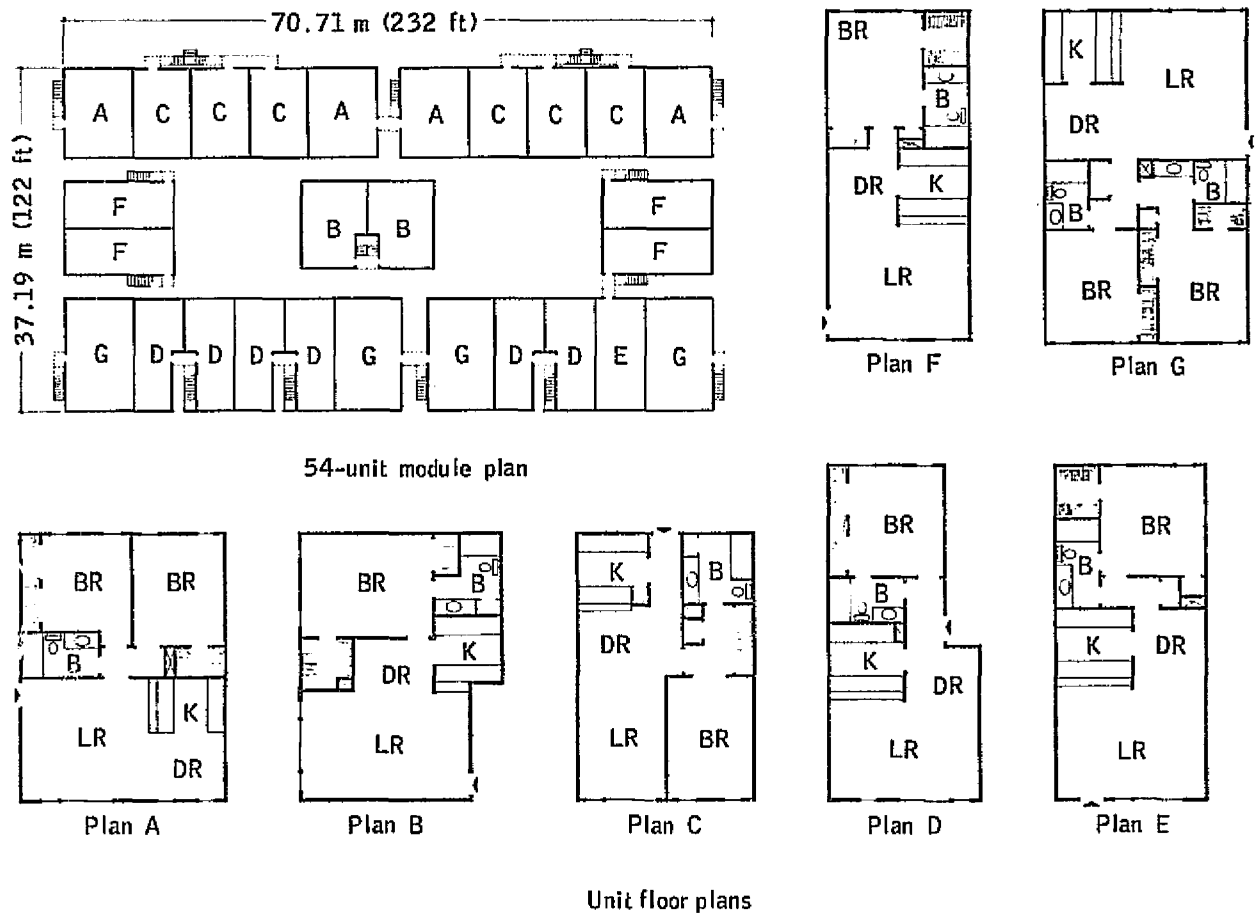


Figure A-17.- Floor and module plans for garden apartments.

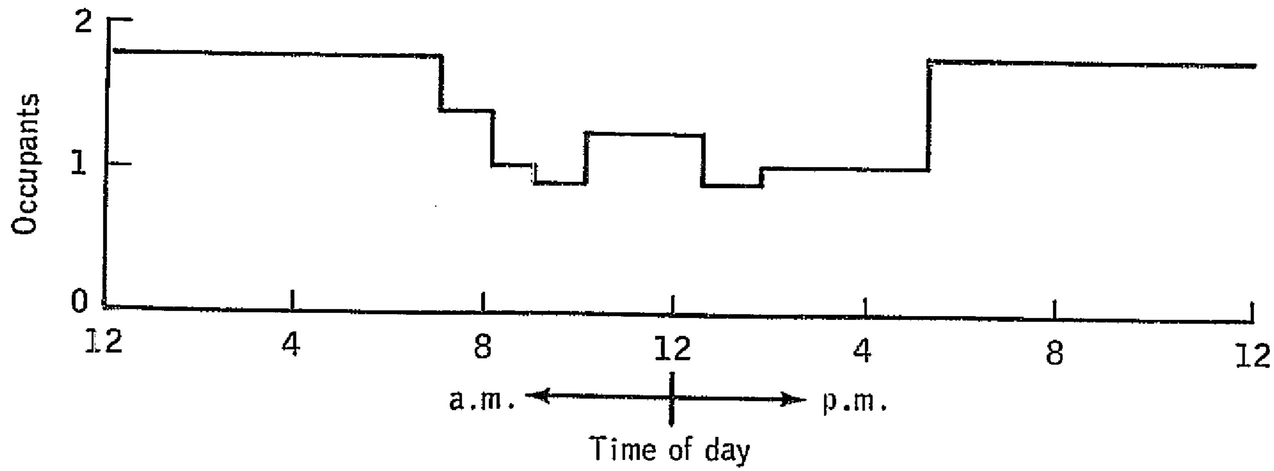
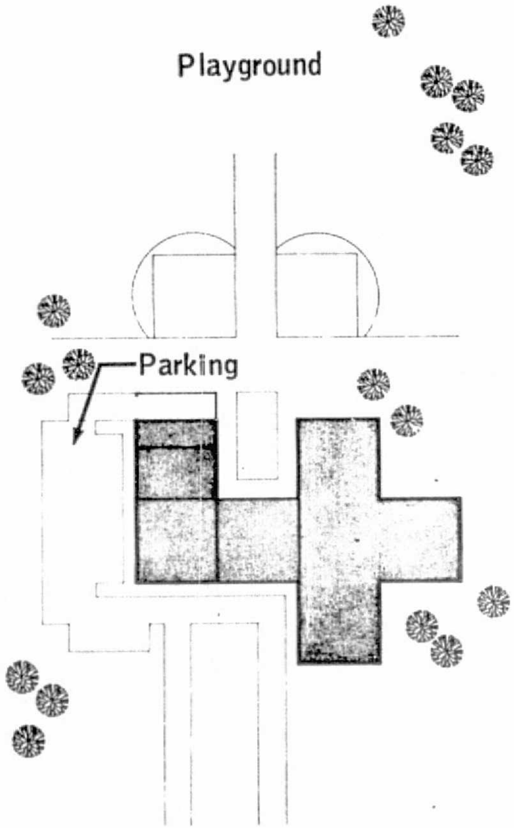
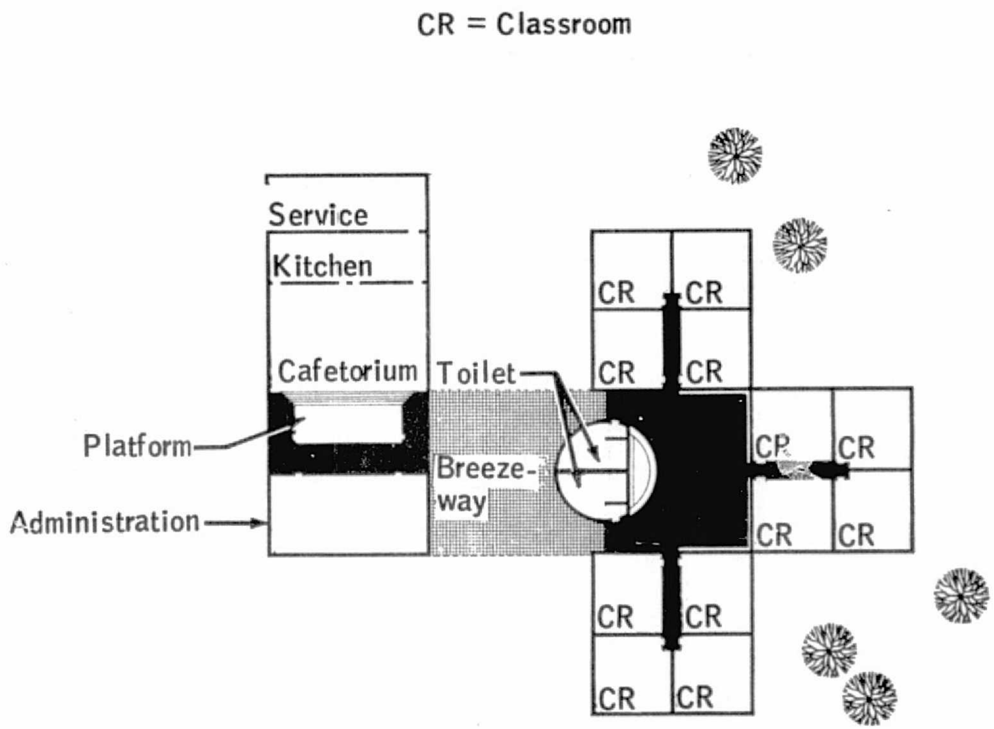


Figure A-18.- Estimated occupancy profile of a garden apartment.



Site



Ground floor

Figure A-19.- Site and floor plans for elementary school.

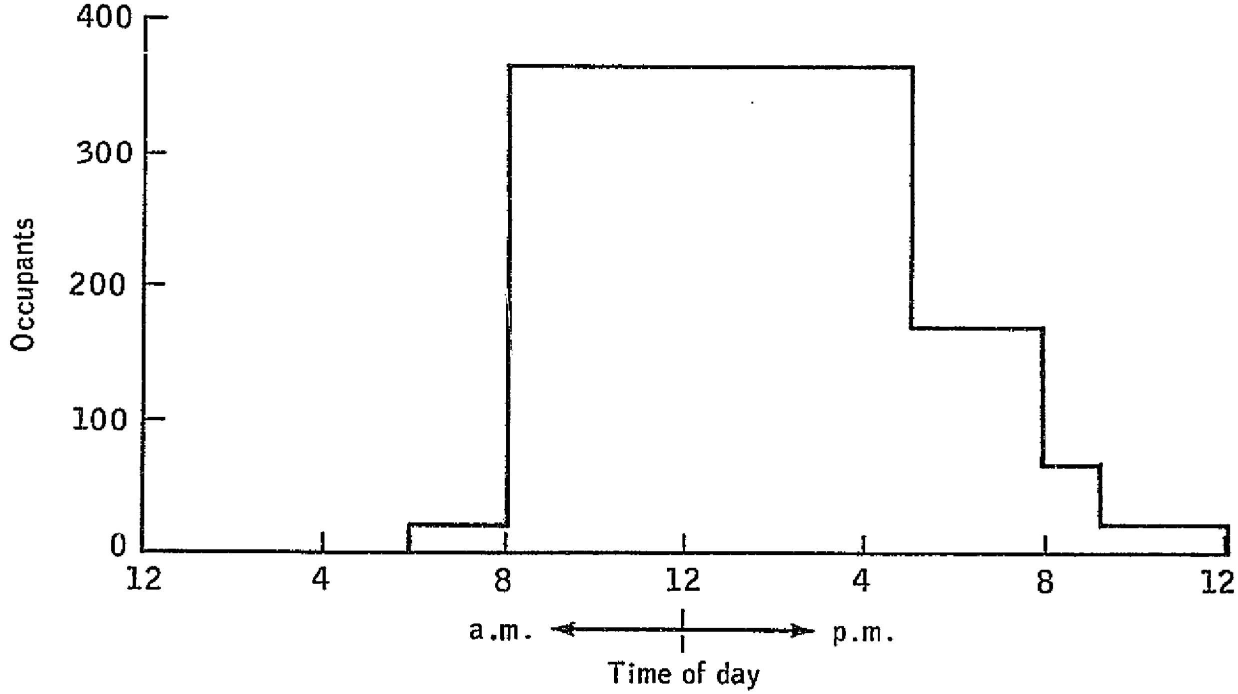


Figure A-20.- Estimated occupancy profile of elementary school.

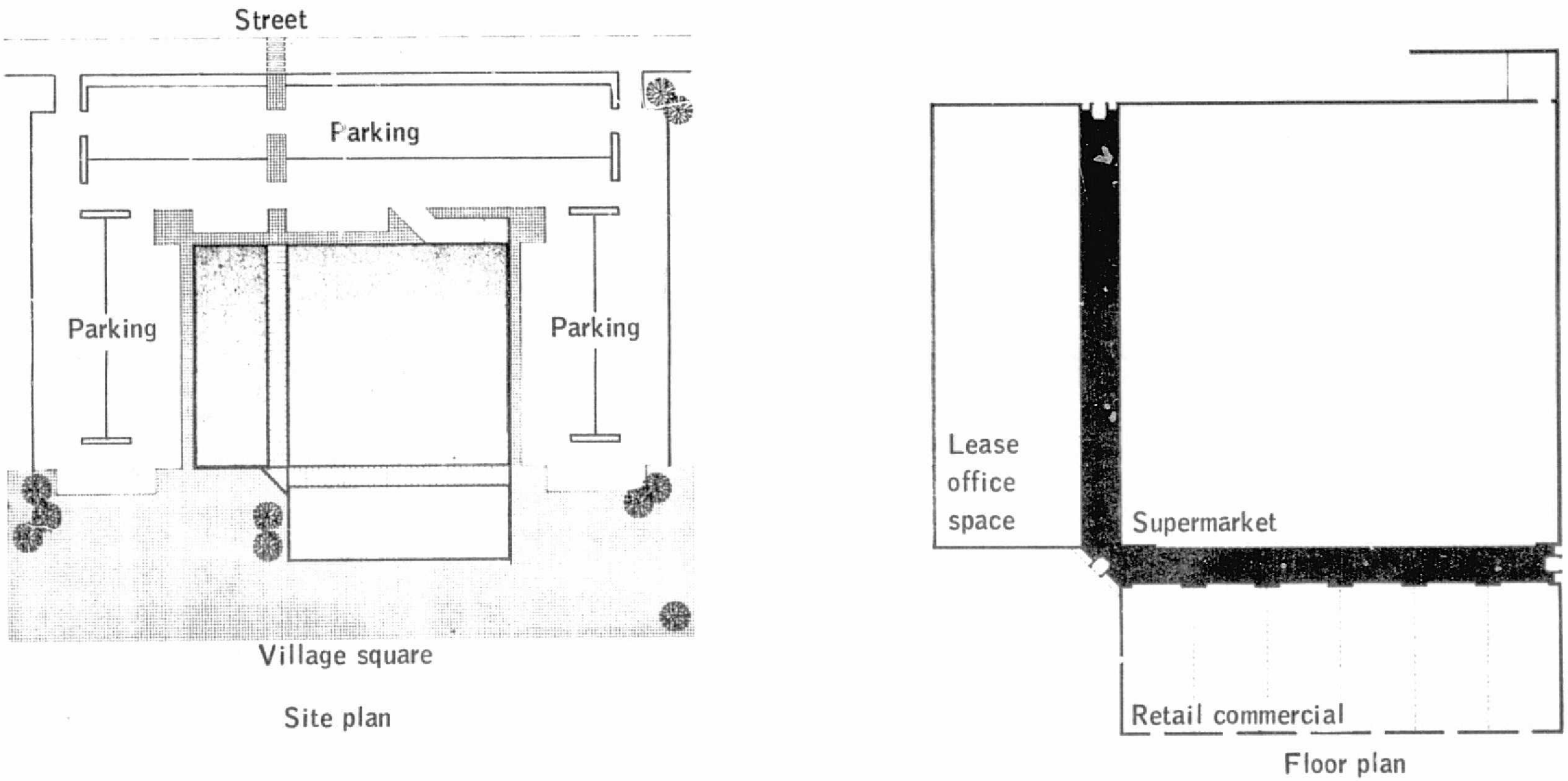


Figure A-21.- Site and floor plans for village commercial center.

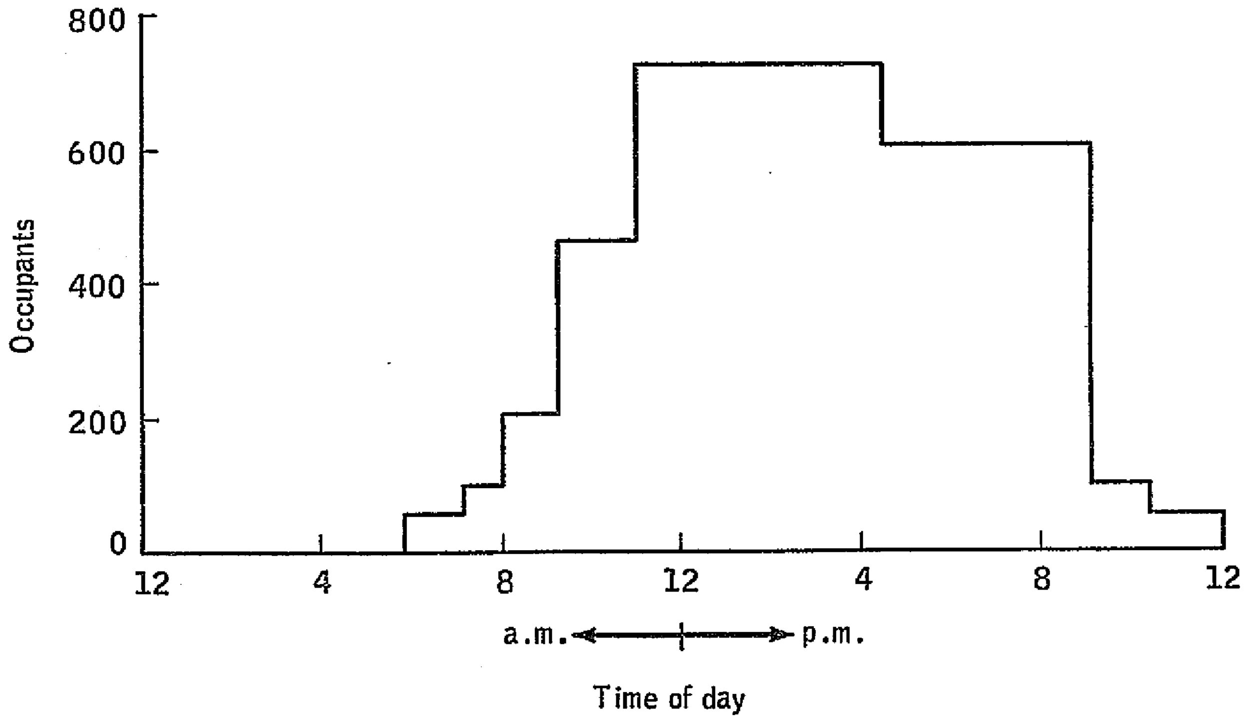
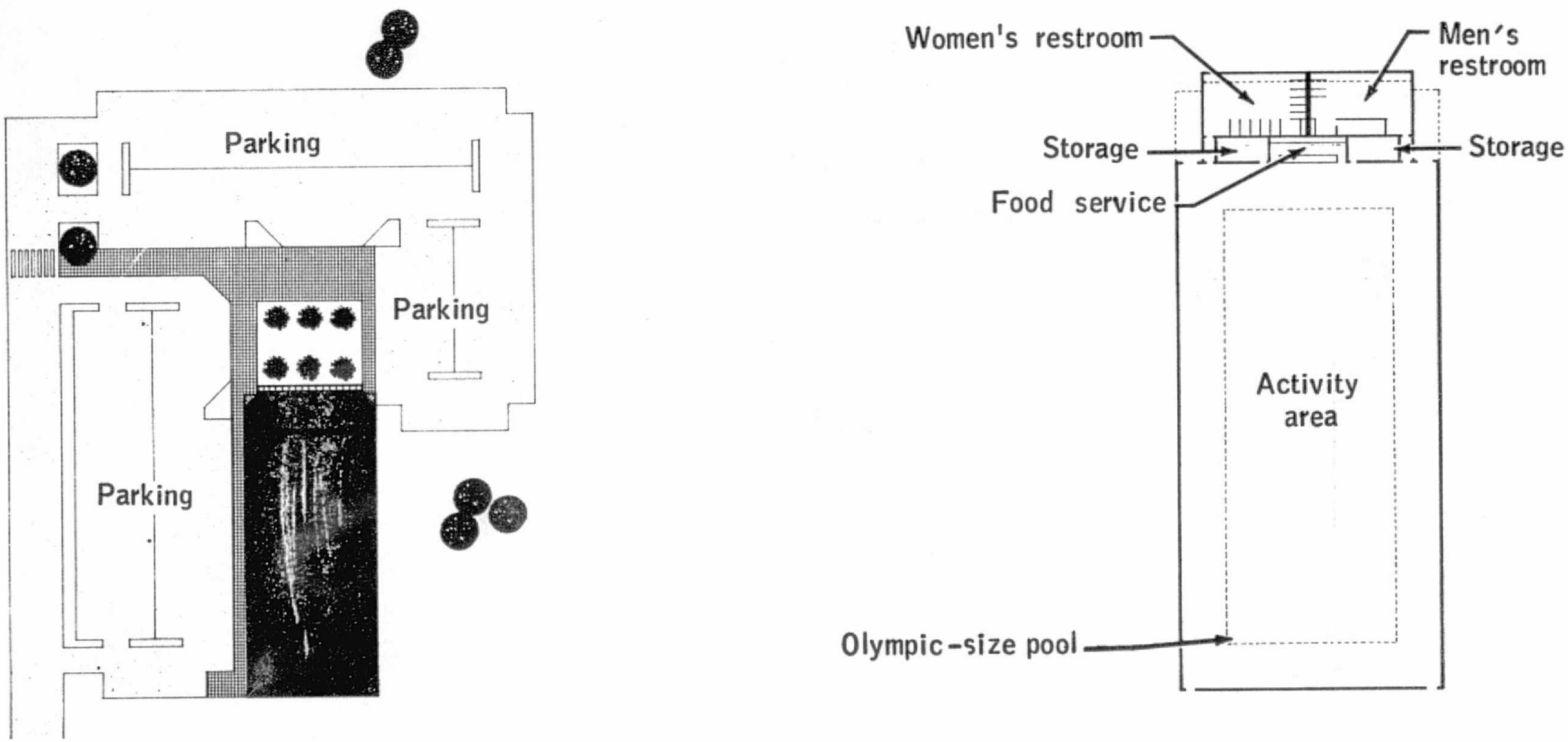


Figure A-22.- Estimated occupancy profile of village commercial center.



Site plan

Floor plan

Figure A-23.- Site and floor plans for recreation building.

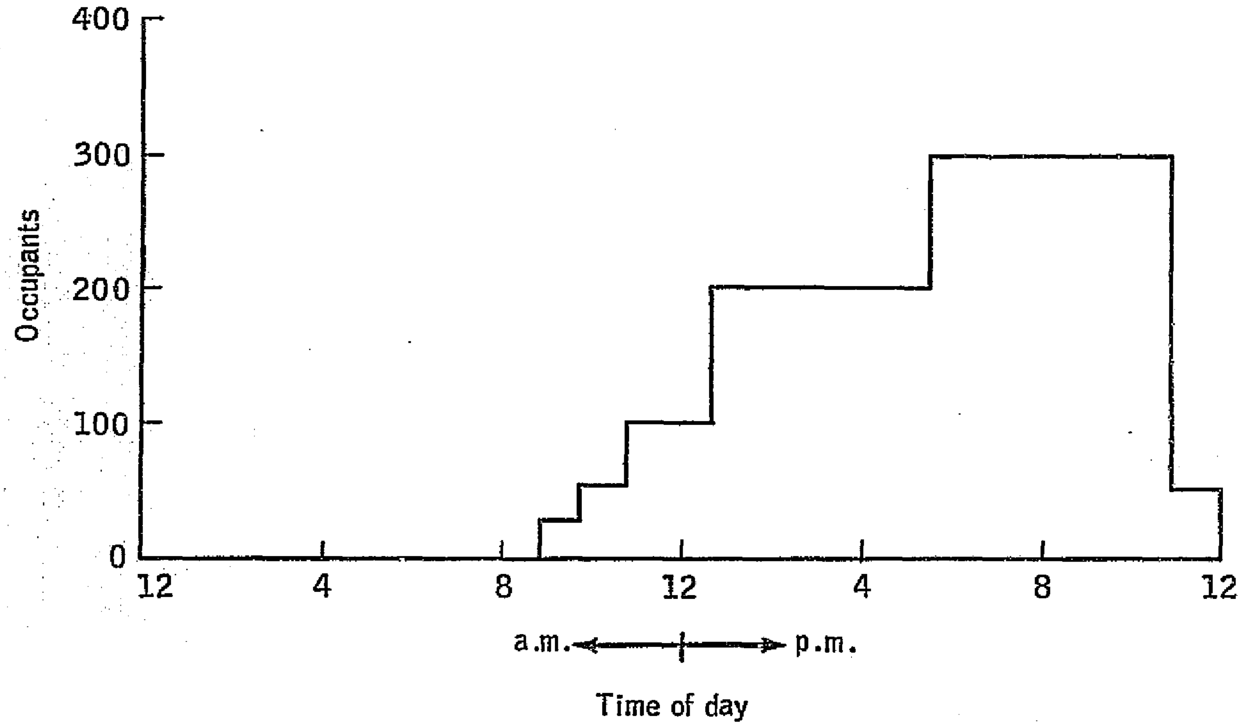


Figure A-24.- Estimated occupancy profile of recreation building.

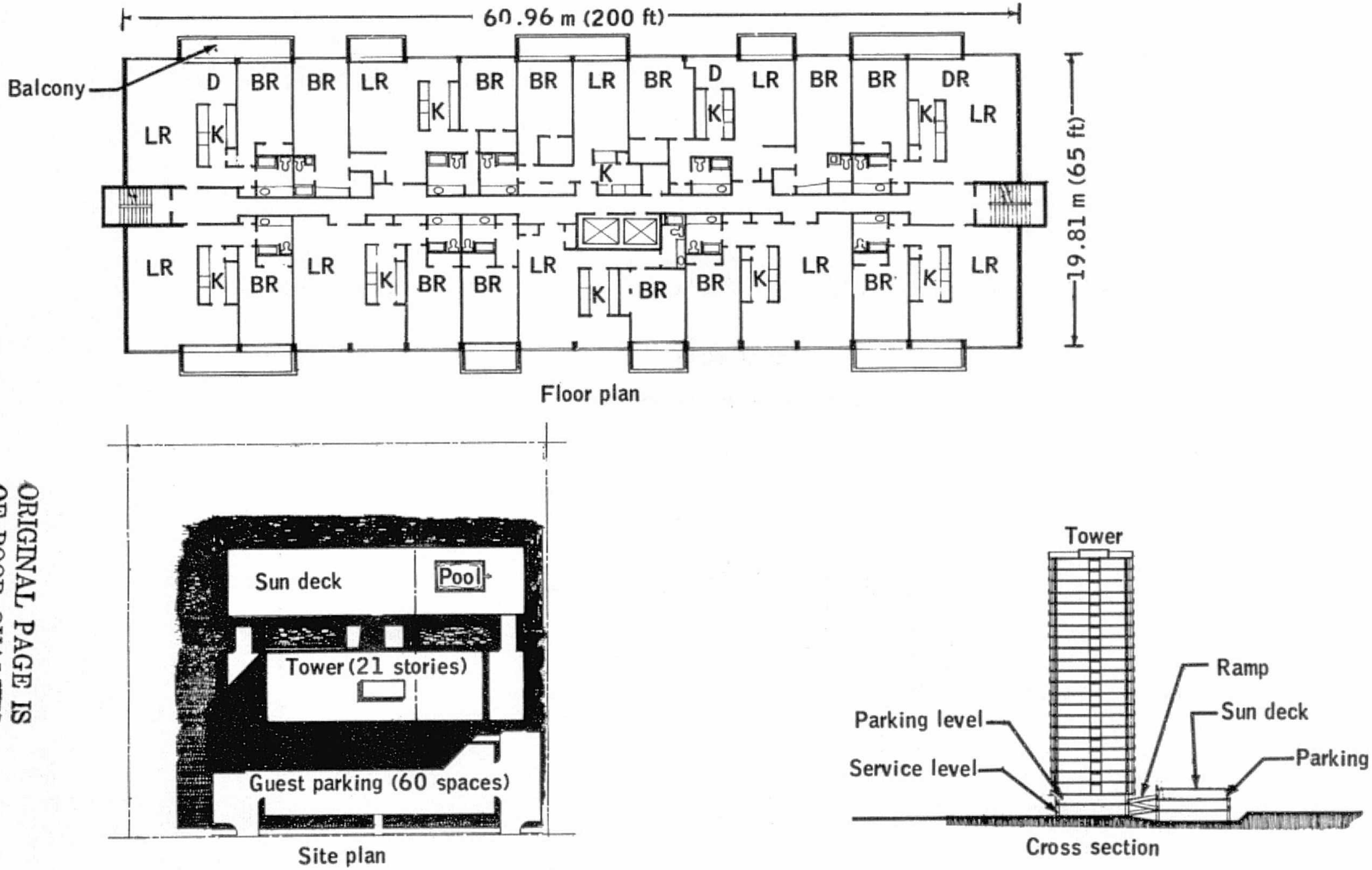


Figure A-25.- Site and floor plans for medium-rise apartments.

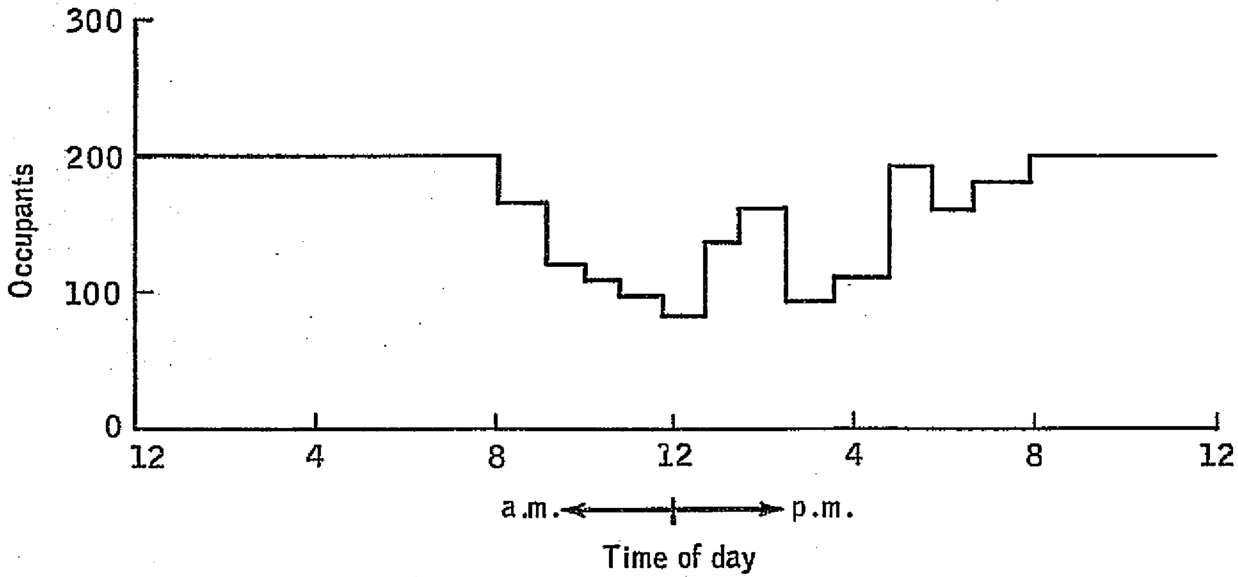


Figure A-26.- Estimated occupancy profile of medium-rise apartments.

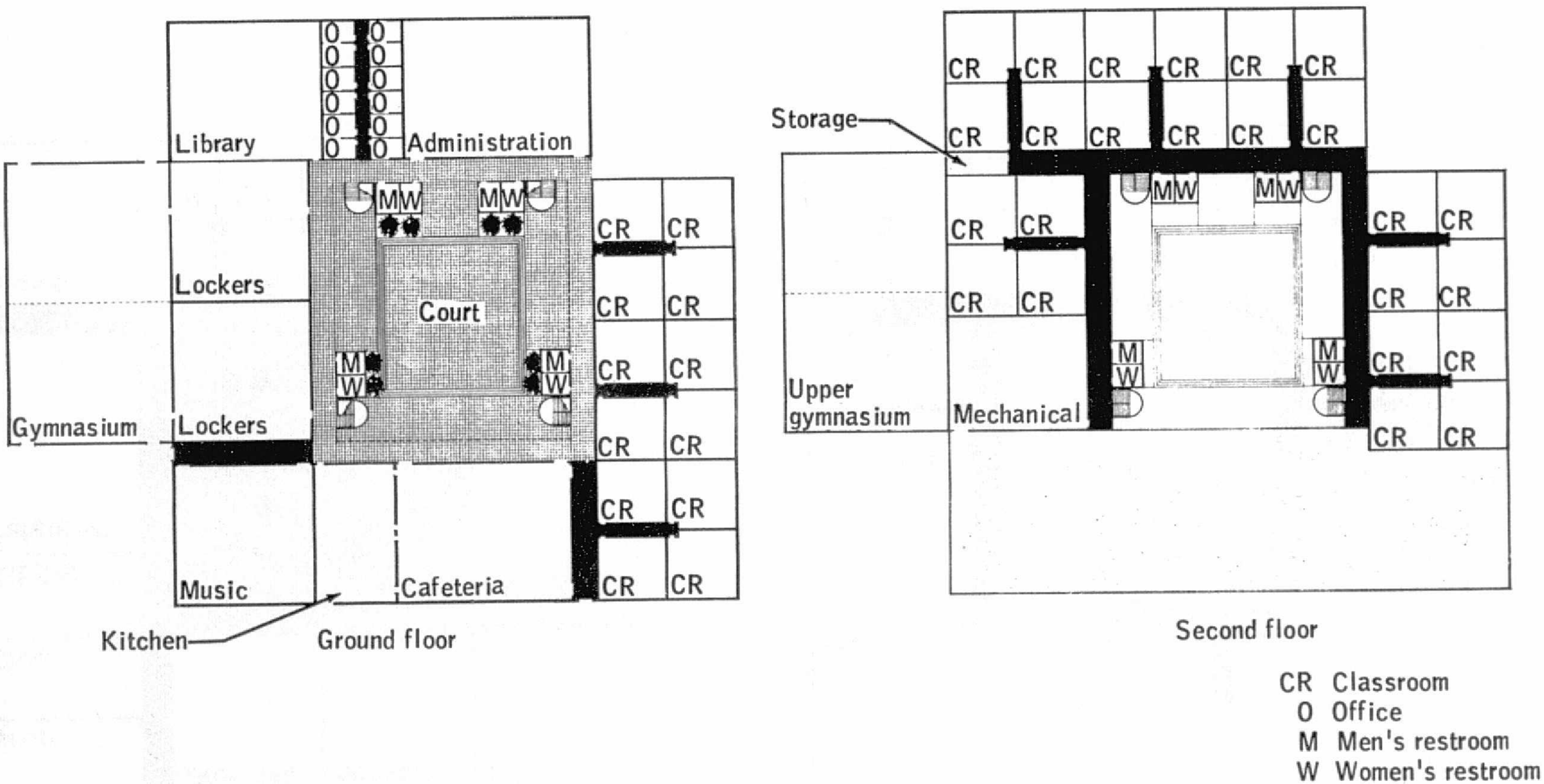


Figure A-27.- Floor plan for middle school.

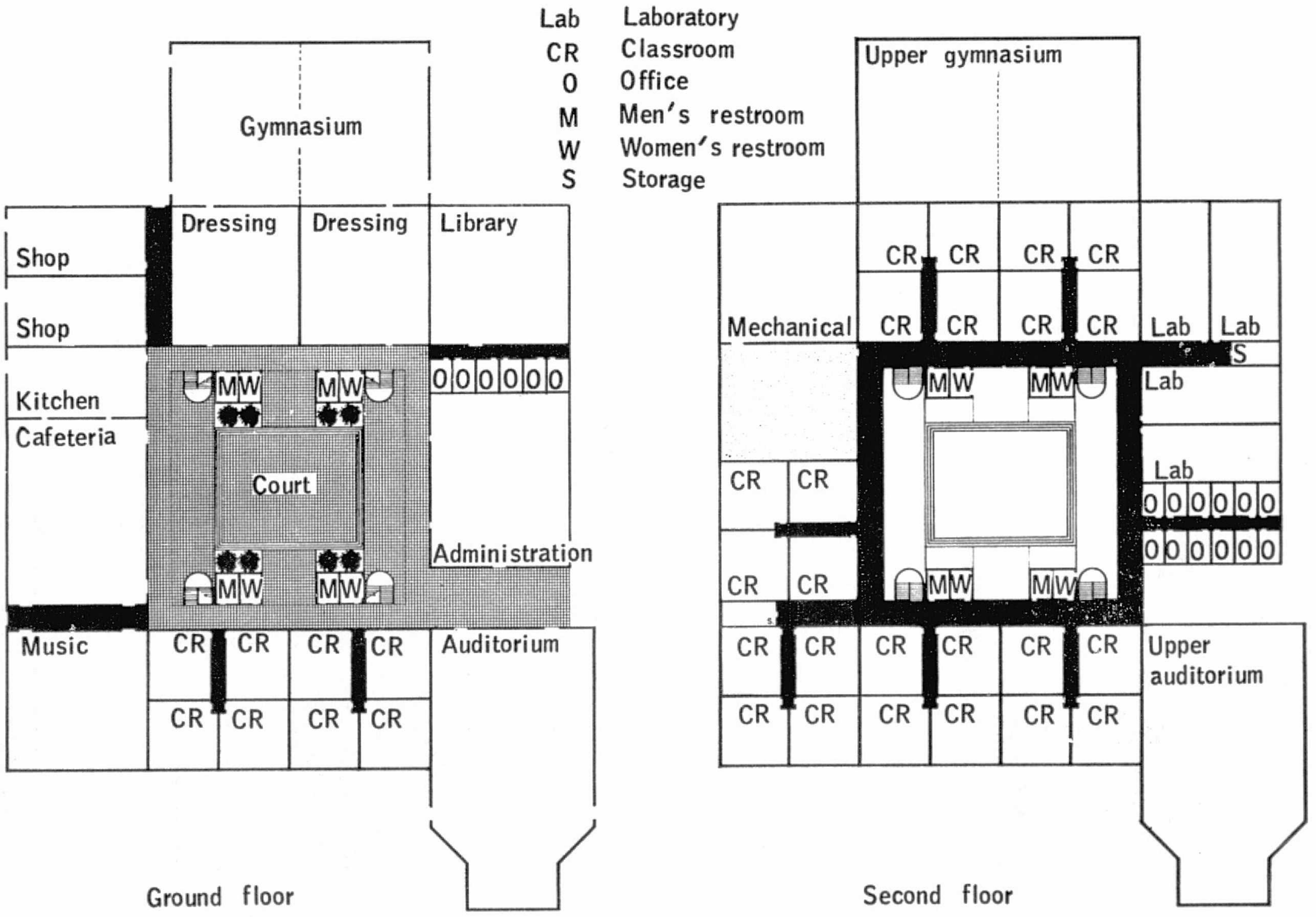


Figure A-28.- Floor plan for high school.

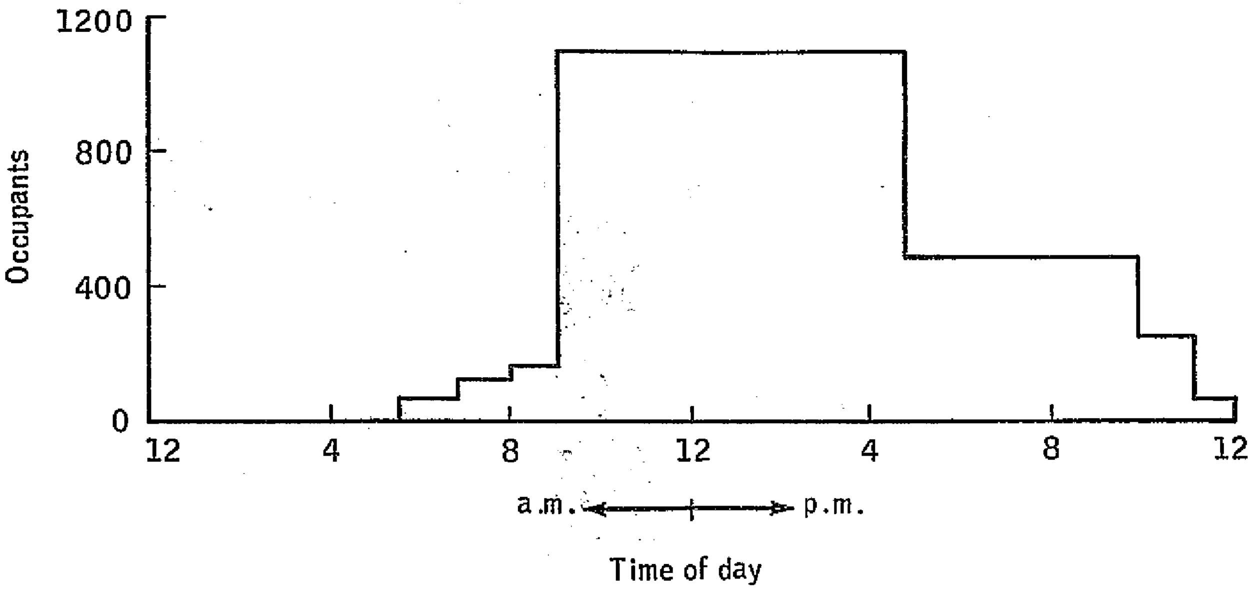


Figure A-29.- Estimated occupancy profile of middle school and high school.

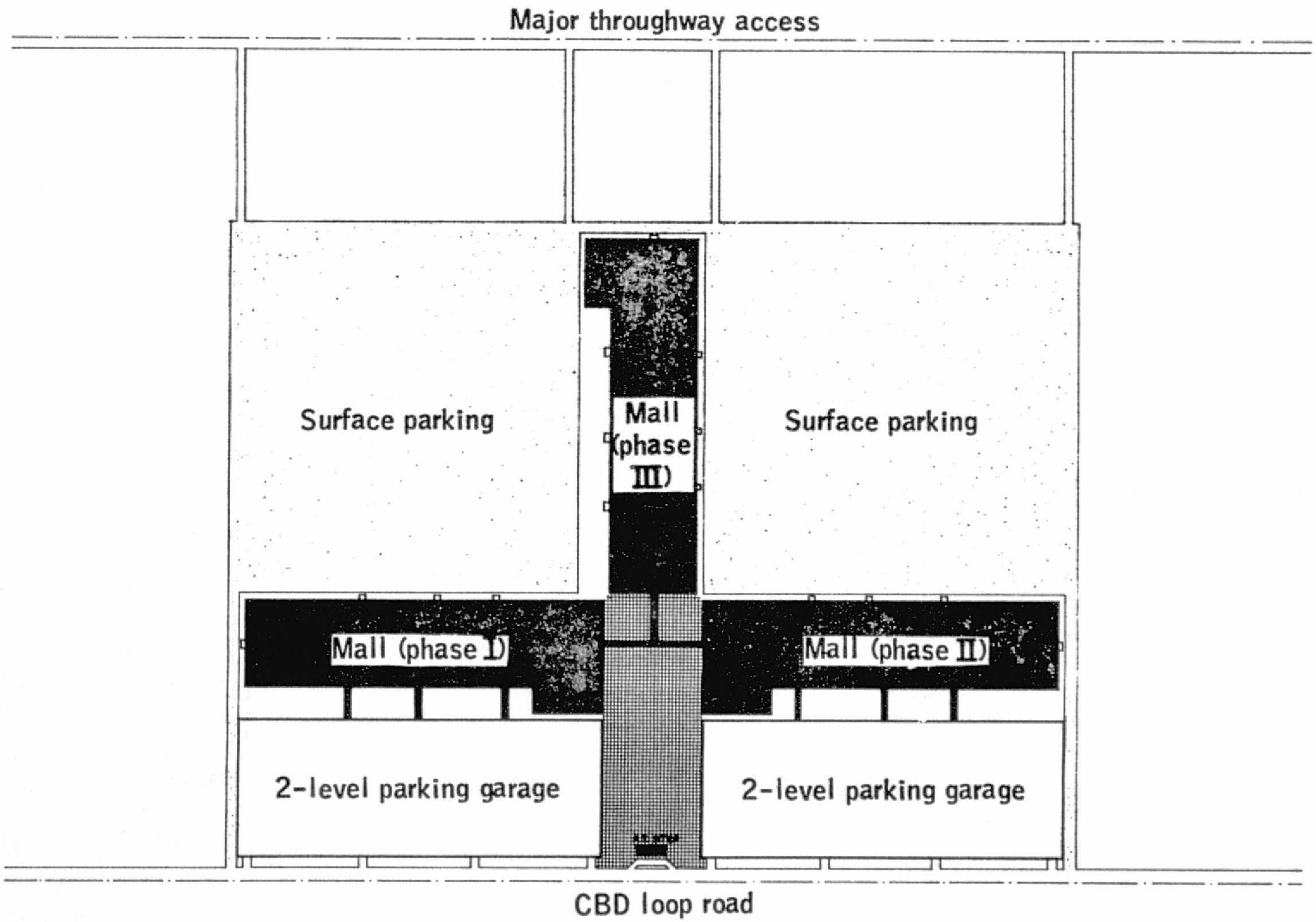


Figure A-30.- Site plan for regional shopping center.

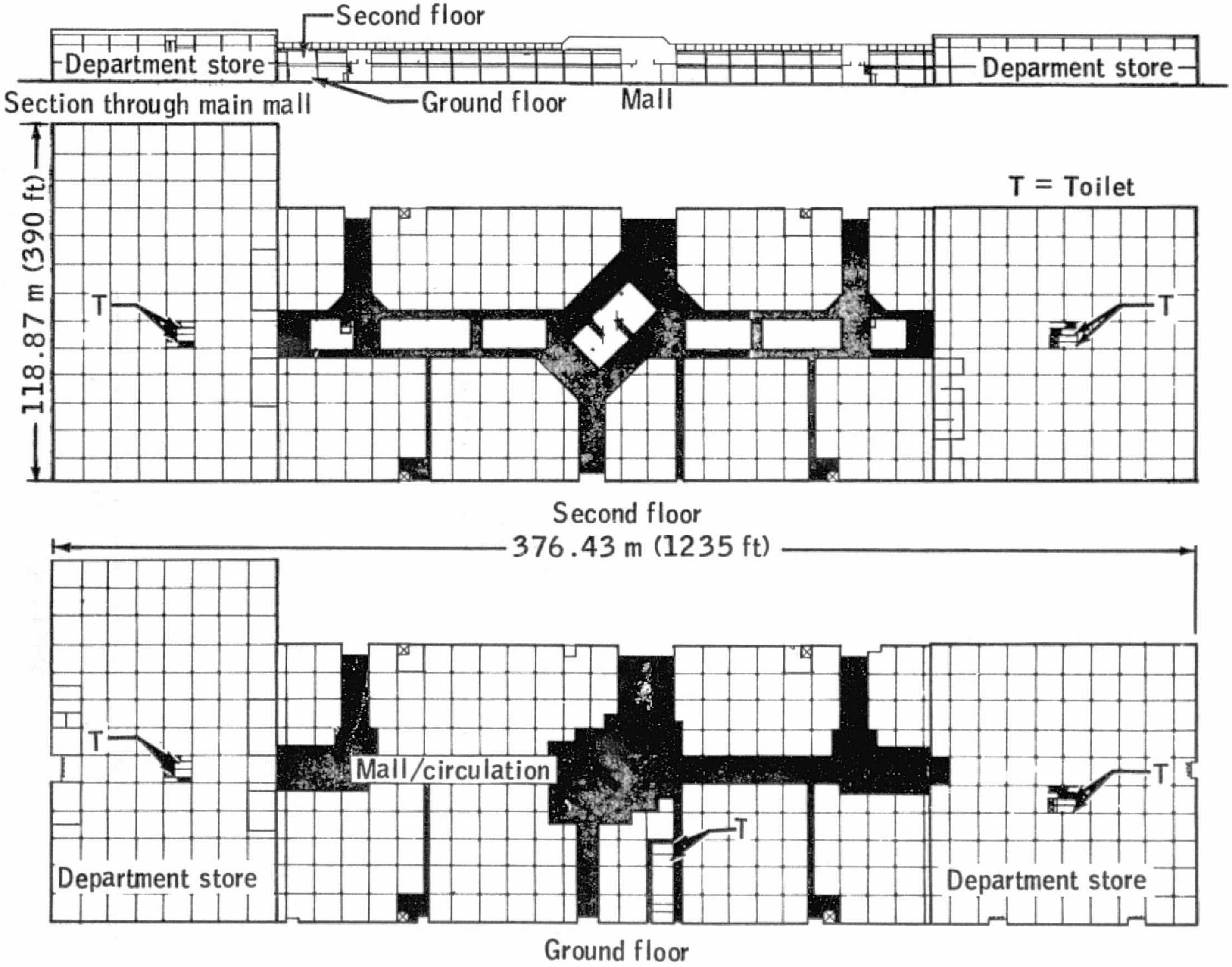


Figure A-31.- Phase I plan for regional shopping center.

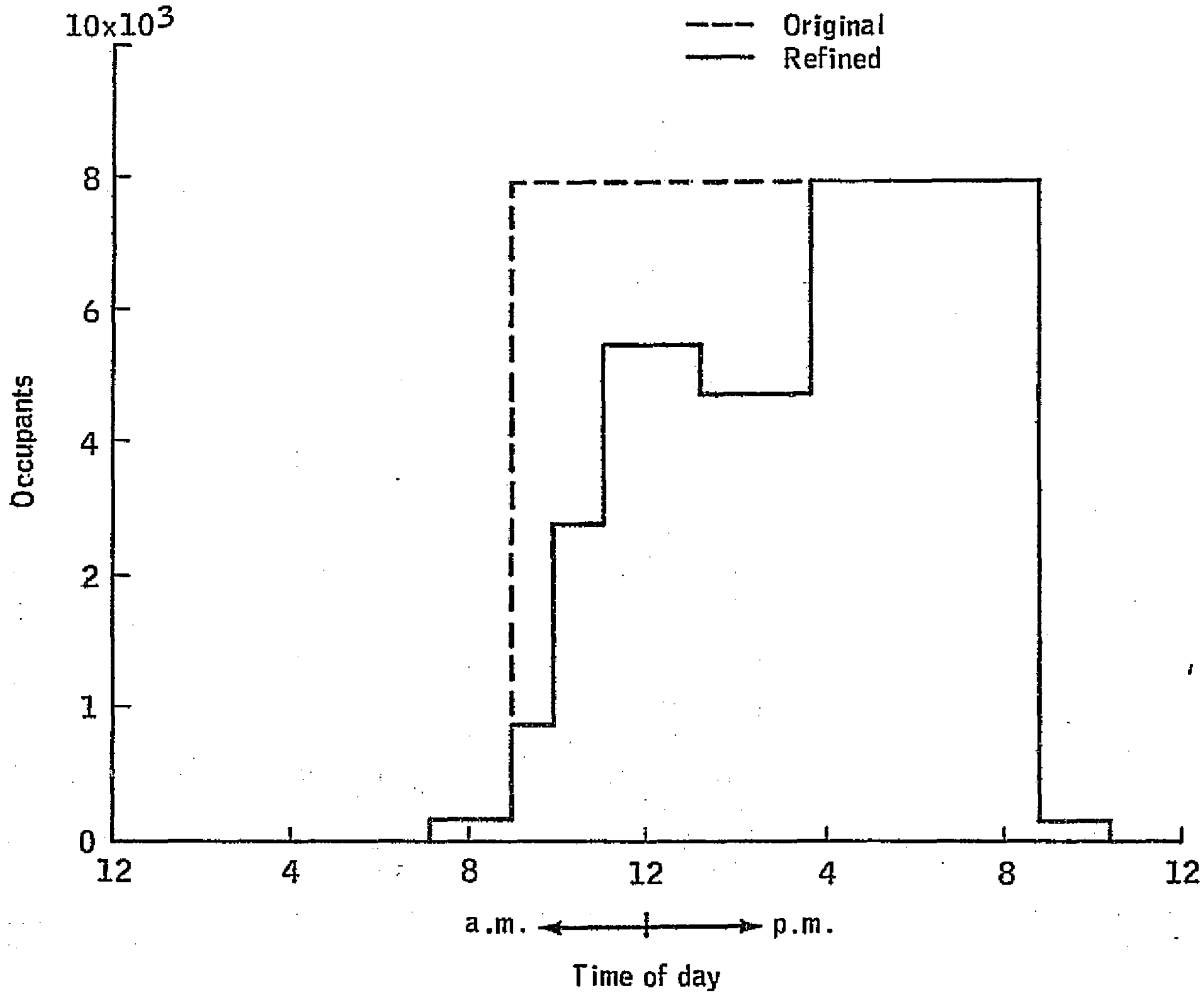


Figure A-32.- Estimated occupancy profile of regional shopping center.

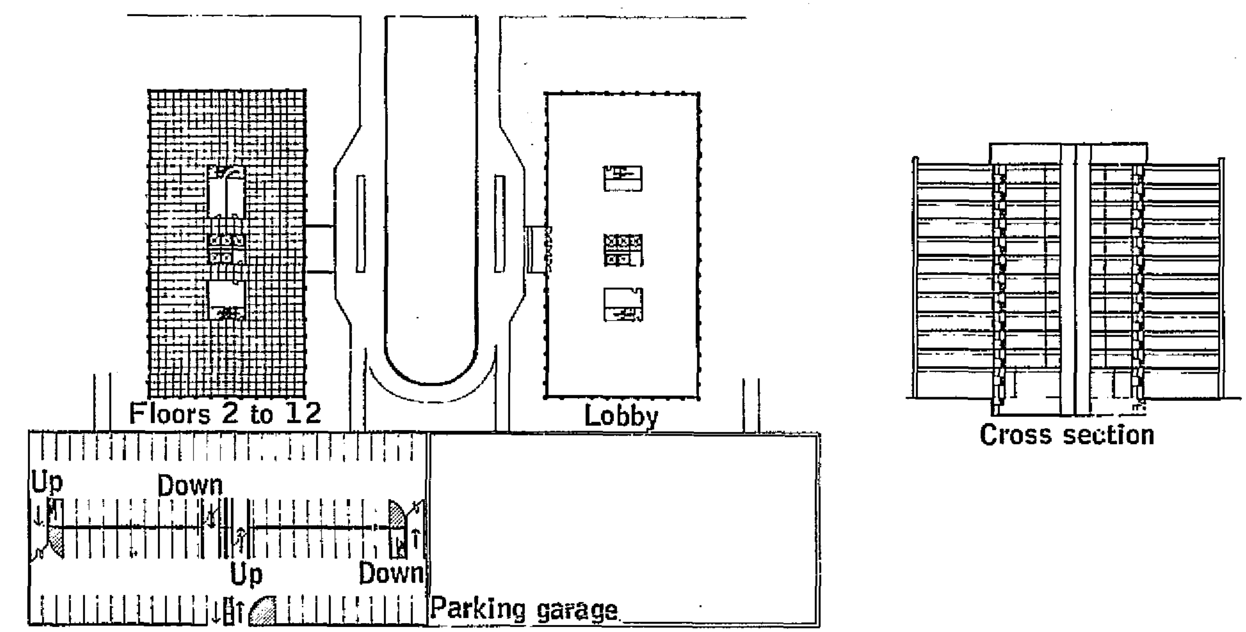


Figure A-33.- Site diagram for office building.

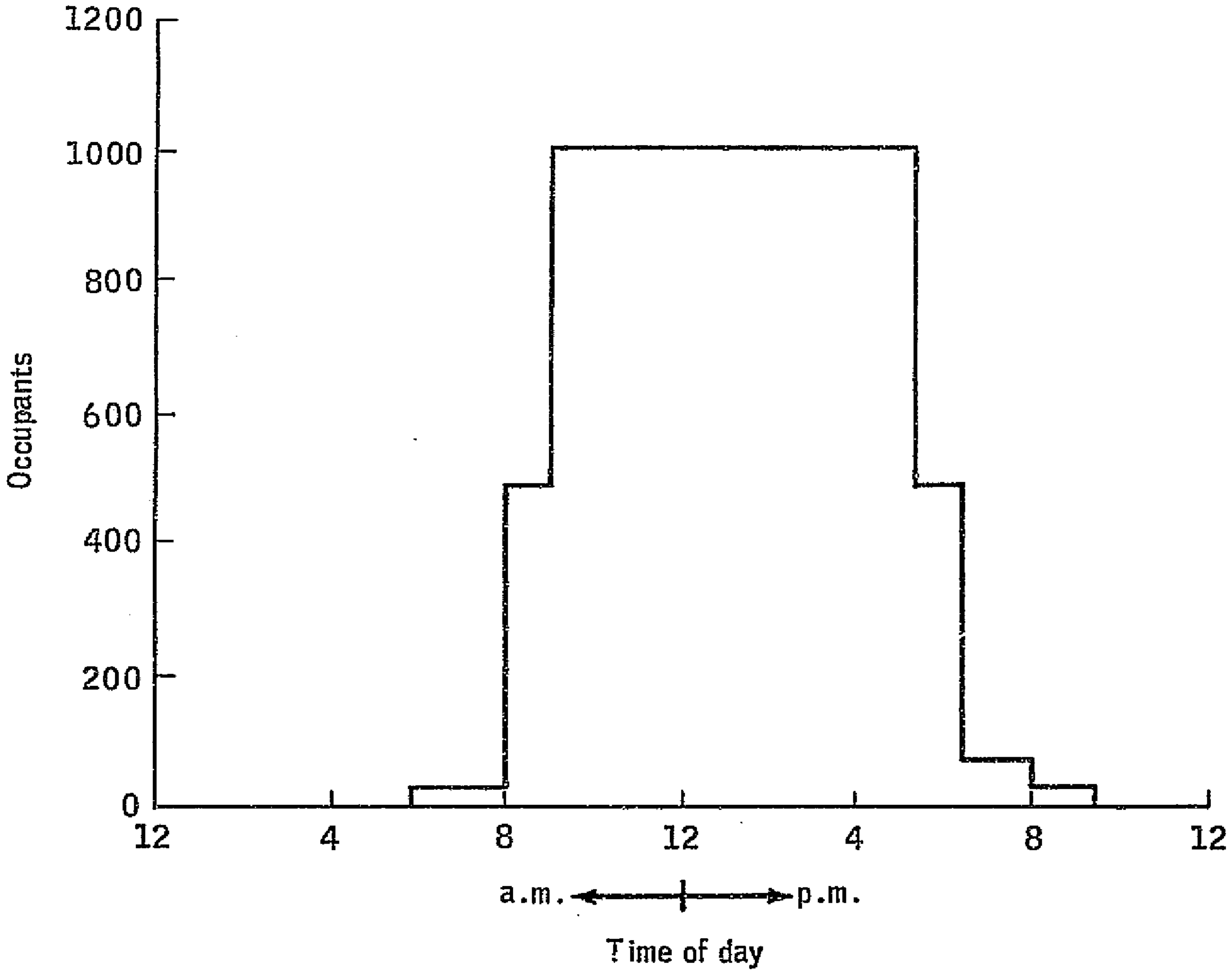


Figure A-34.- Estimated occupancy profile of high-rise office building.

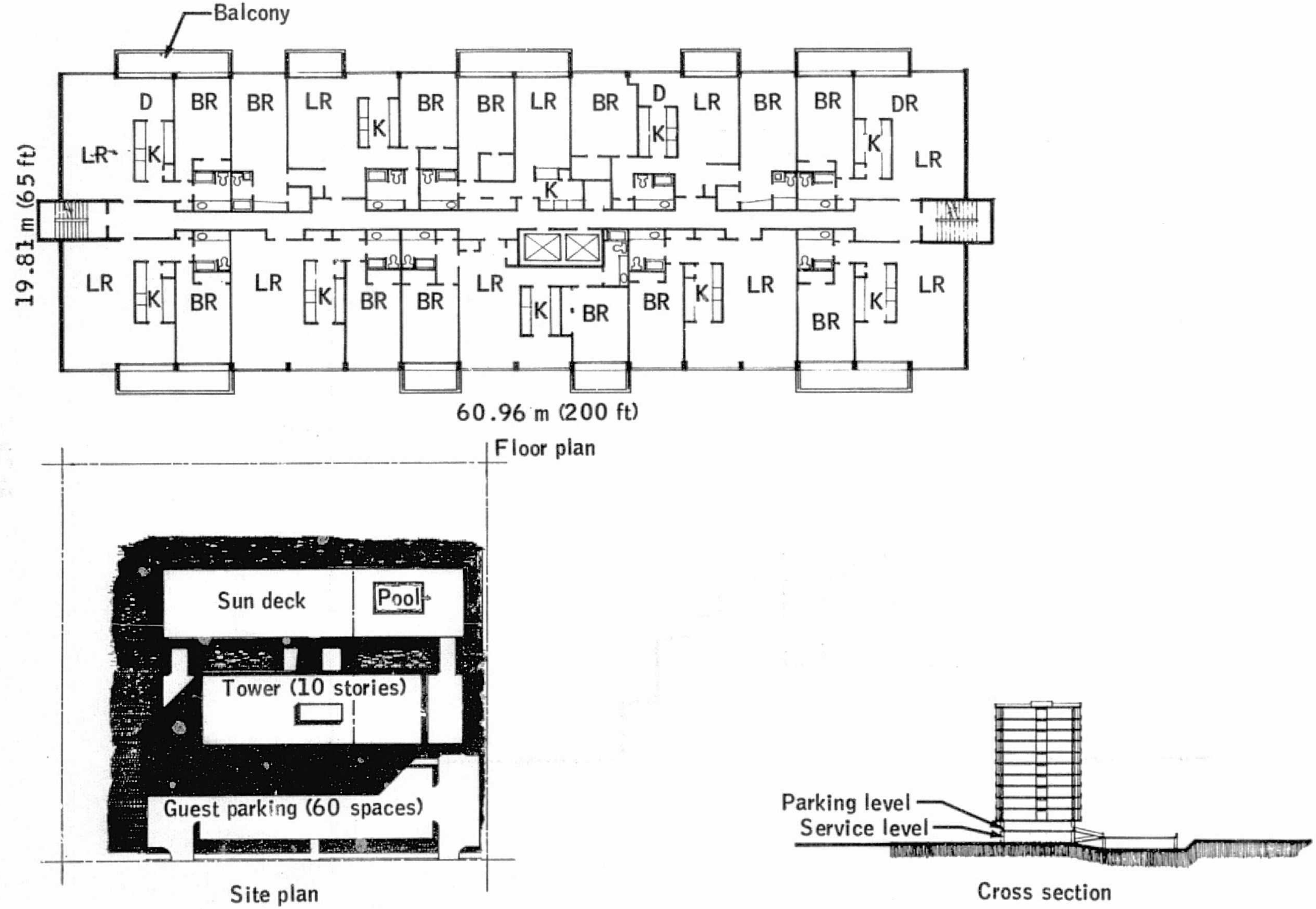


Figure A-35.- Site and floor plans for high-rise apartments.

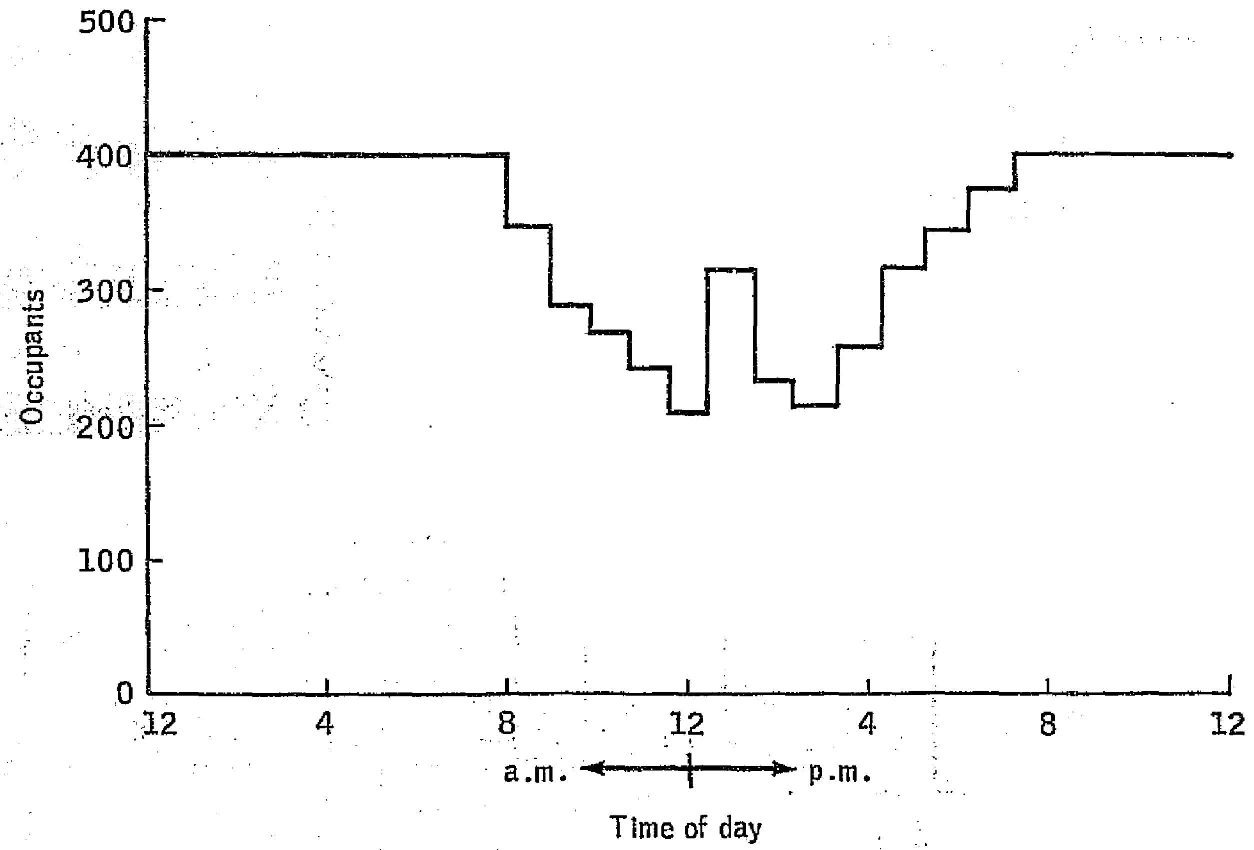


Figure A-36.- Estimated occupancy profile of high-rise apartments.

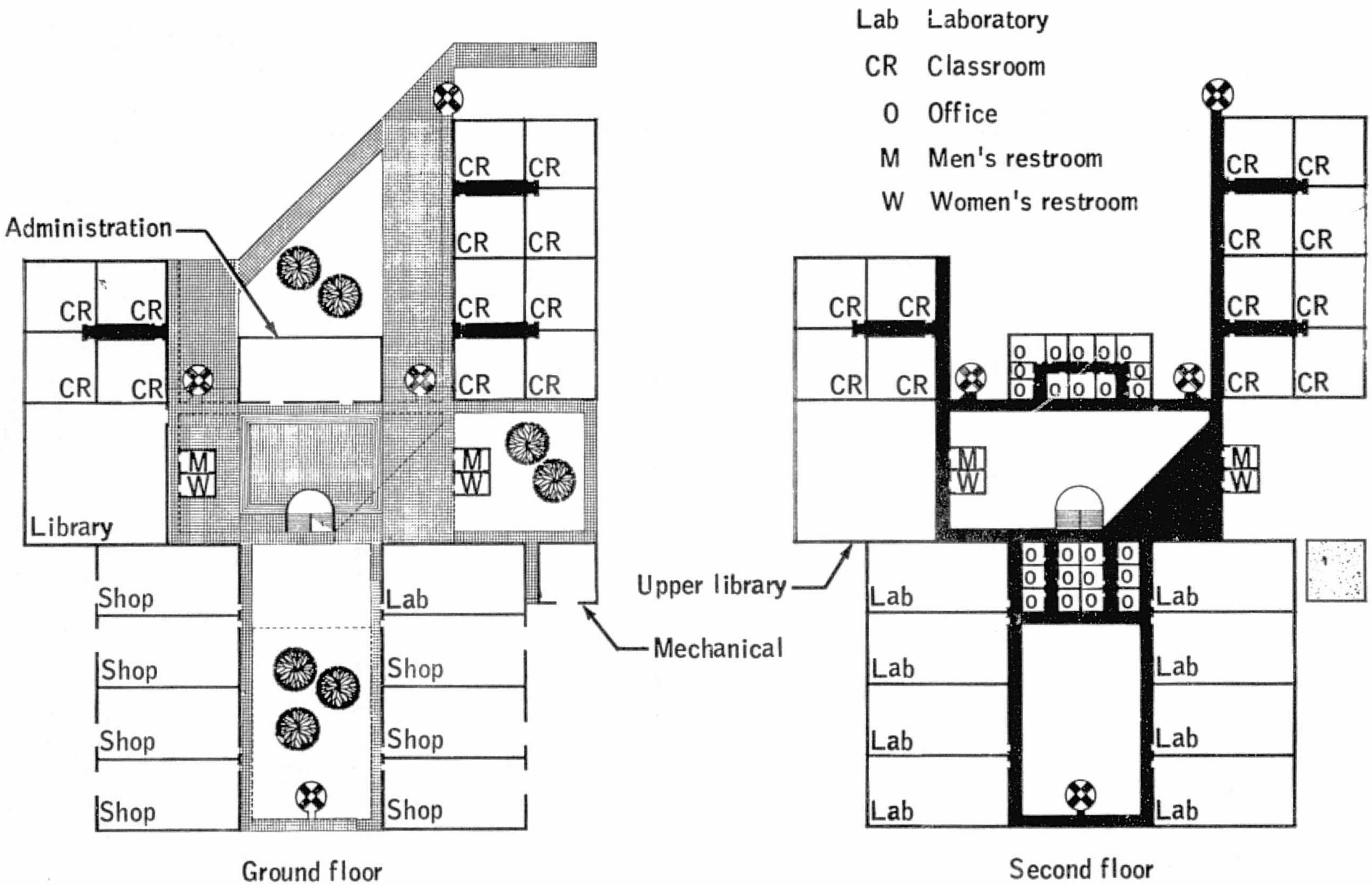


Figure A-37.- Floor plan for community college.

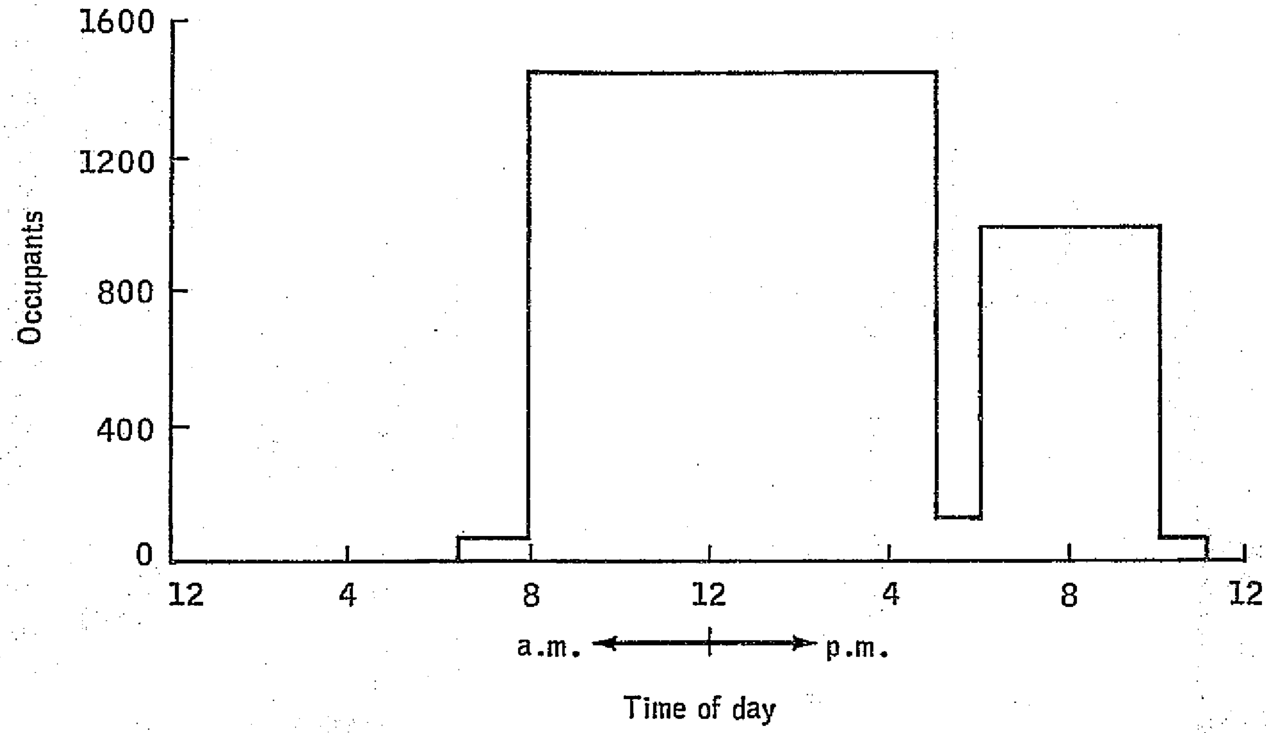


Figure A-38.- Estimated occupancy profile of community college.

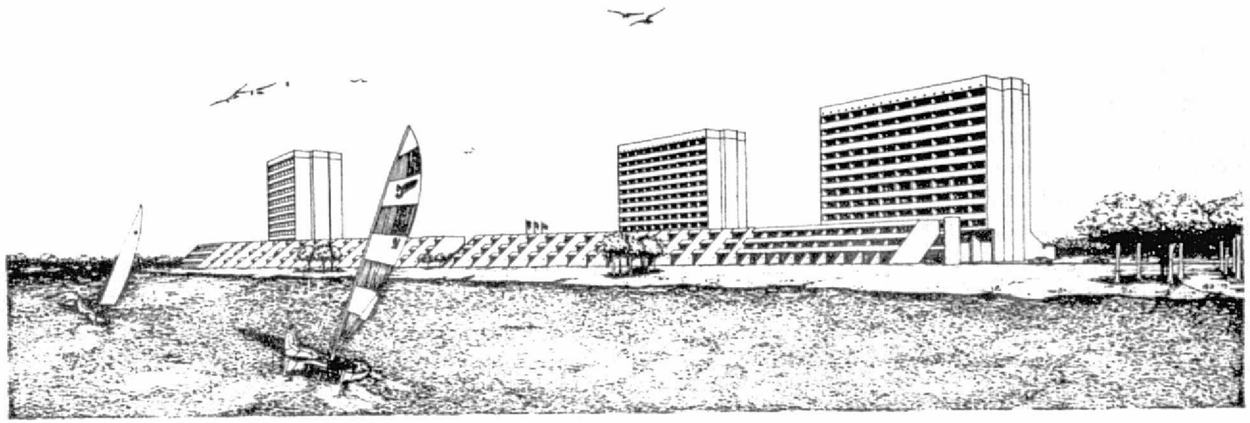
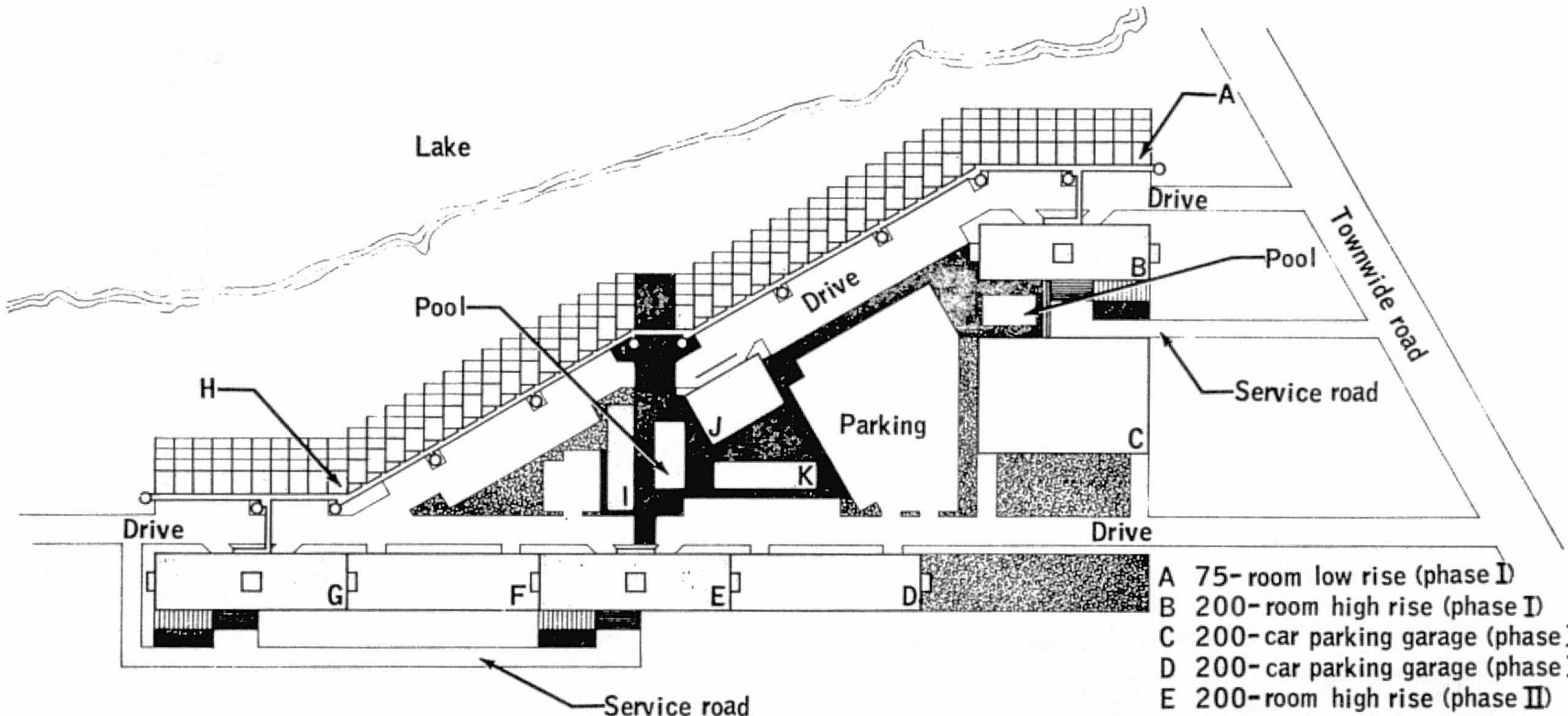


Figure A-39.- Inn and hotel complex.



A 75-room low rise (phase I)
B 200-room high rise (phase I)
C 200-car parking garage (phase I)
D 200-car parking garage (phase II)
E 200-room high rise (phase II)
F 200-car parking garage (phase II)
G 200-room high rise (phase II)
H 75-room low rise (phase II)
I Banquet room (phase II)
J Restaurant (phase II)
K Banquet room (phase II)

Figure A-40.- Site plan for inn and hotel complex.

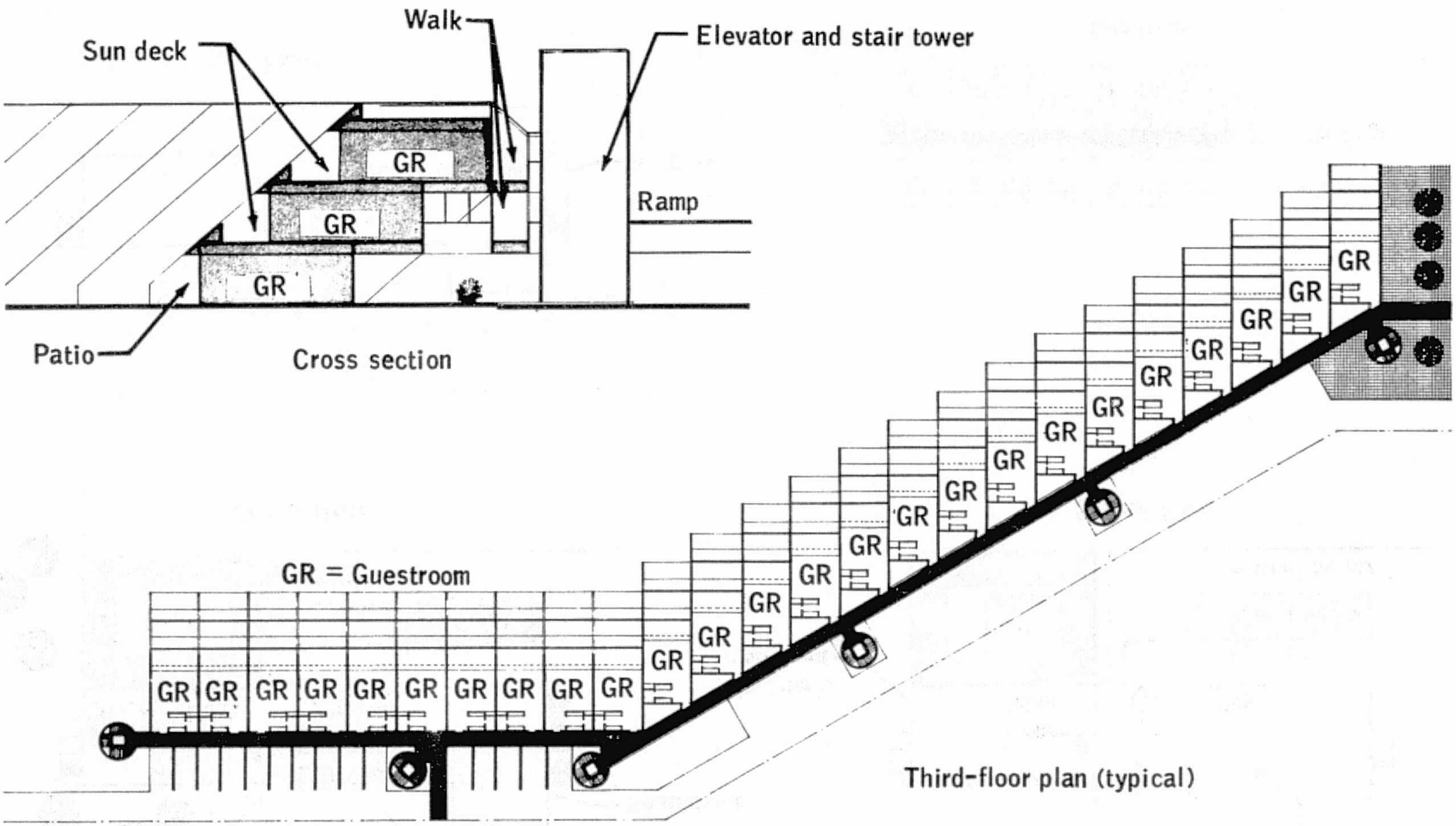


Figure A-41.- Phase II plan for low-rise inn. The phase I plan is similar.

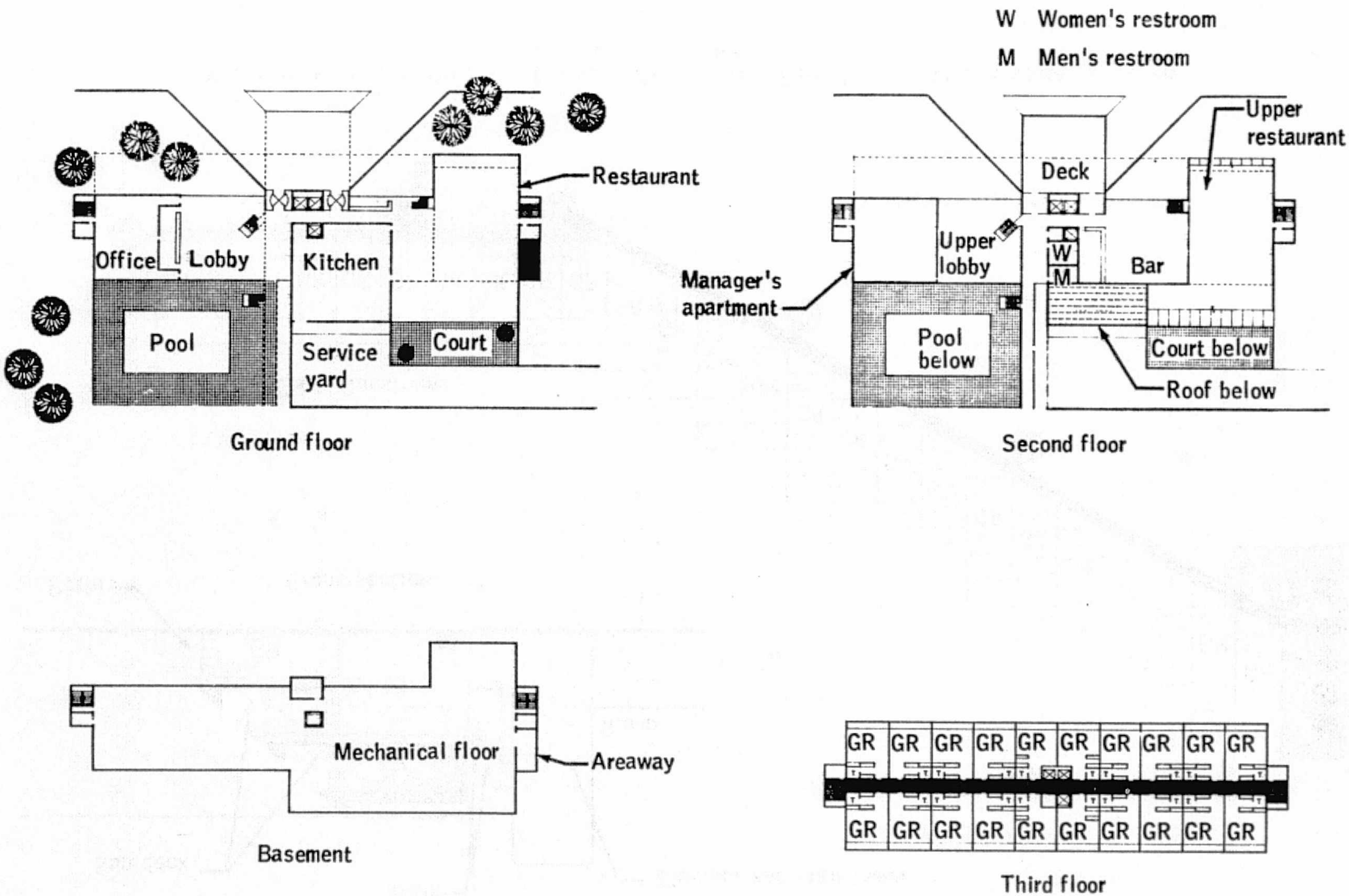


Figure A-42.- Floor plan for high-rise hotel. The plan for floors 4 through 12 is identical to the third-floor plan.

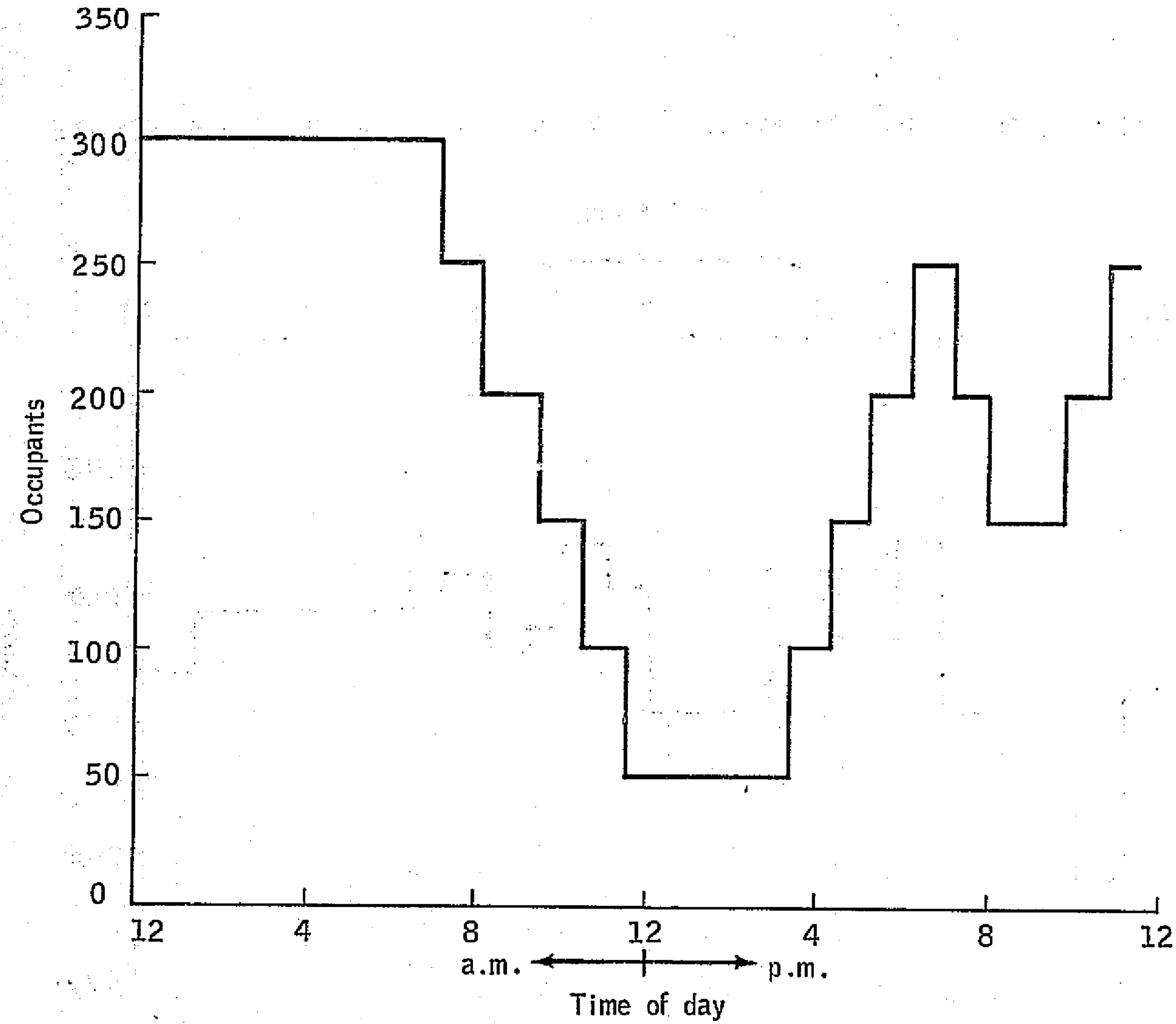


Figure A-43.- Estimated occupancy profile of low-rise inn.

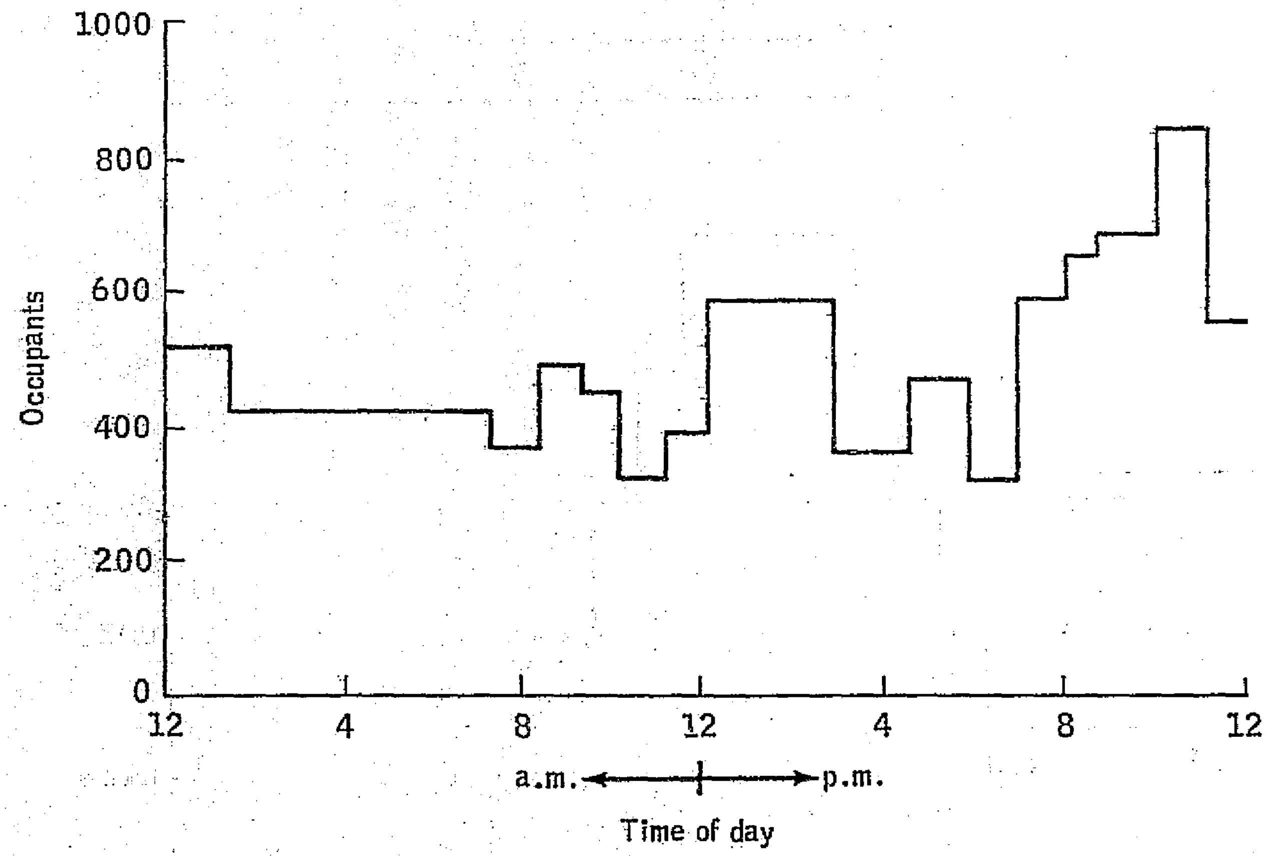


Figure A-44.- Estimated occupancy profile of high-rise hotel.

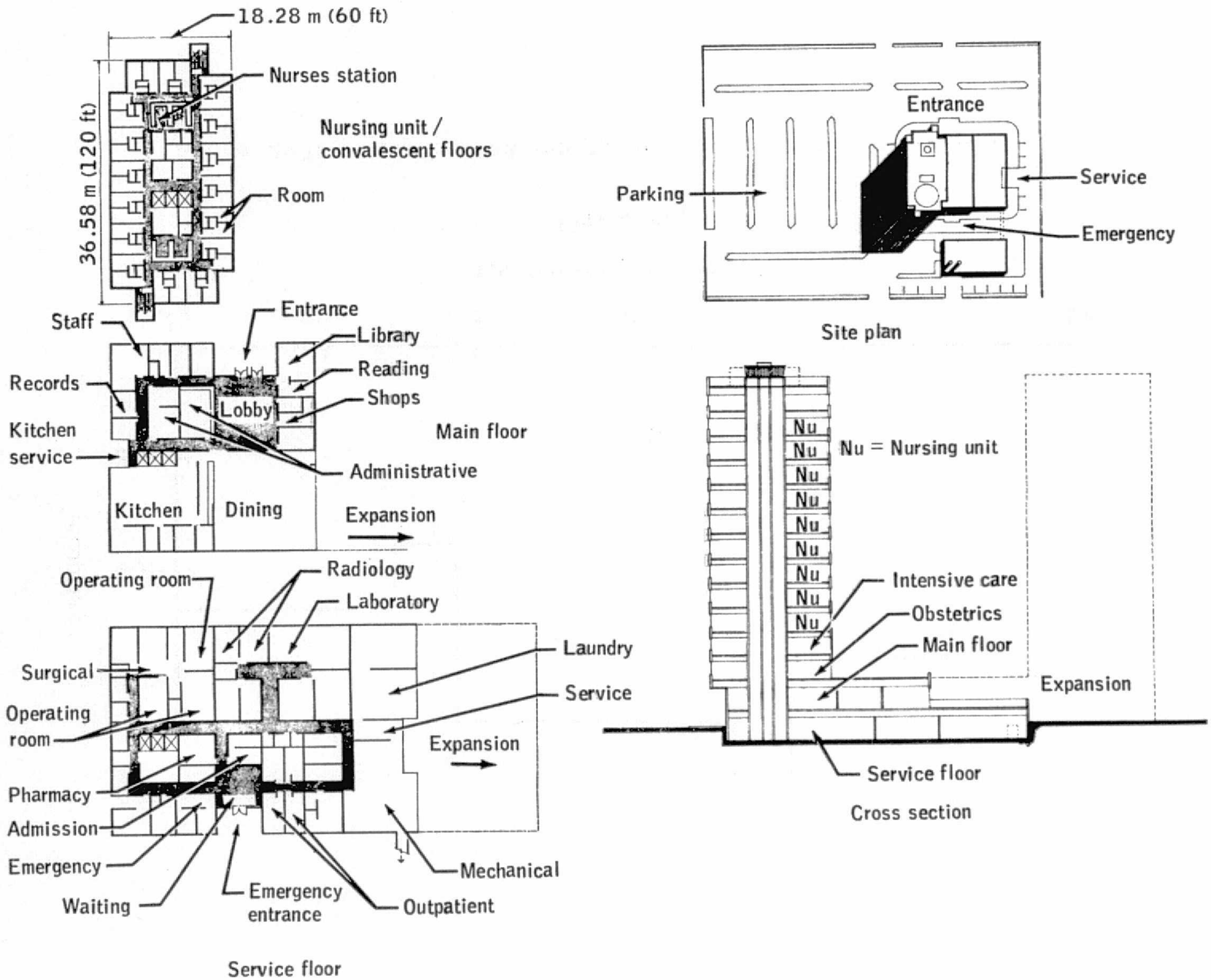


Figure A-45.- Site and floor plans for hospital.

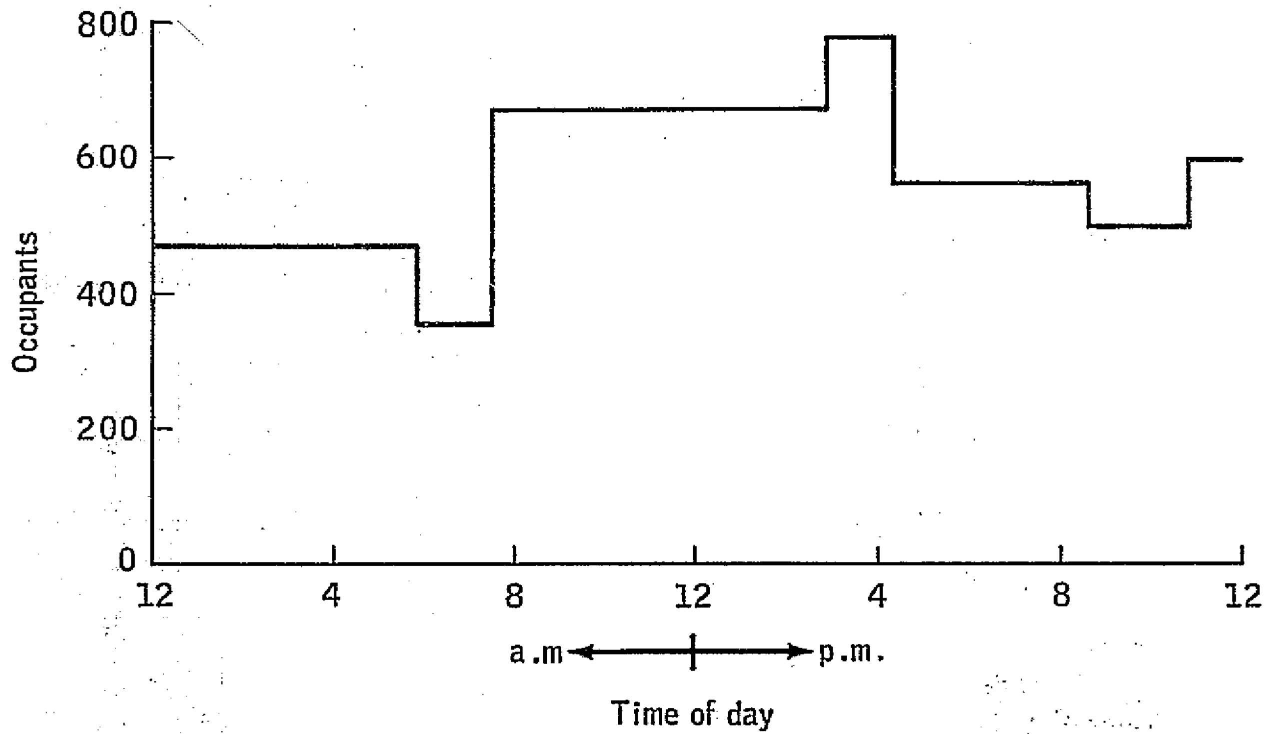


Figure A-46.- Estimated occupancy profile of hospital.

APPENDIX B

CONCEPTUAL DESIGN SUPPORTIVE DATA FOR MIUS

DESIGN STRATEGY

The model community consists of three basic, distinctly different community elements: a neighborhood, a village center, and a central business district (CBD). Design options were selected to evaluate the characteristics of the modular integrated utility systems (MIUS) for each of the three elements.

The size of the community segment served by an MIUS was also important. Some correlation between the results of this study and community segments of other sizes is desirable because much of the residential housing is constructed in smaller segments. Consideration was given to a developer-sized MIUS; i.e., an MIUS sized to serve a project of the size generally constructed by an individual developer. Also considered was an MIUS sized to serve a planned unit development (PUD), which is an intermediate-sized development often on the scale of a village in this study.

The result of this design strategy was that two options are required to evaluate all characteristics of the elements and to accommodate the two development sizes. In both options, the single-family detached units are all-electric. A four-pipe heating, ventilation, and air-conditioning (HVAC) distribution system distributes hot and chilled water to all higher density areas in both options.

Option I

In option I (a 29-MIUS-unit facility), an MIUS is placed at each community element; i.e., the neighborhood, the village center, and the CBD. Figure B-1(a) illustrates the placement of 29 MIUS plants throughout the community. In option I, a central potable water treatment system is provided for the entire community. All three MIUS types are sized according to the electrical requirements of the community segment served. An MIUS in option I is representative of a developer-sized MIUS.

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Option II

Option II (an 8-MIUS-unit facility), consists of two MIUS types: the village complex MIUS, which is designed to serve the village center and the three adjacent neighborhoods, and the CBD. The placement of the eight MIUS plants that serve the community is shown in figure B-1(b). Potable water treatment is provided within each MIUS; there is no central potable water treatment system as in option I. Electricity is supplied to the neighborhoods by the MIUS in the village center. The MIUS size in option II is representative of the PUD-sized MIUS.

UTILITY LOADS DEFINITION

The loads of the major subsystems (electrical power, HVAC, water, and solid waste) were defined by determining the utility requirements of each building type, or facility, and then combining those requirements. This combination expresses the utility loads of community components serviced by an MIUS.

Electrical Power Loads

The sizes of the various MIUS types were determined by the electrical power requirements. Therefore, in both options I and II, the MIUS was sized in accordance with the electrical demand of that portion of the community served by an MIUS.

Each building and individual dwelling unit was analyzed, and a 24-hour profile of the domestic load was developed. The domestic load was defined as lights, electric oven (where applicable), other appliances, and all other electrical loads except environmental conditioning loads. Where necessary, MIUS-peculiar loads were added. In developing the electrical profiles for the dwelling units, the diversity among units was considered. This resulted in a demand for each group that was less than the accumulated total of each dwelling unit.

The electrical load profile for all 713 single-family dwellings in a neighborhood (fig. B-2(a)) was developed by combining data on energy consumption with a diversity factor (ref. B-1). The profile in figure B-2(a) was multiplied by the appropriate number to determine the single-family component of the load on an MIUS. This profile does not include the electrical load for environmental conditioning; that load is included in the total electrical demand profile for the neighborhood.

Figure B-2(b) shows the electrical load profile for the 324 townhouses in one neighborhood. This profile was developed from data by Hittman Associates (ref. B-2). The garden apartments load profile (fig. B-2(c)) represents the demand over 24 hours for the 324 apartments in one neighborhood. This profile is the result of a 1973 Urban Systems Project Office (USPO) study of a 648-unit garden apartment complex in Houston, Texas. The profile was halved for the community apartments. The neighborhood elementary school profile (fig. B-2(d)) was also developed from an earlier USPO study based on a school within the Houston Independent School District. The Monday through Friday profiles for the elementary, middle, and high schools are the same and are scaled to the square meter of each building.

The local shopping center in a village center had the electrical load profile shown in figure B-2(e). The profile was developed from data collected and published by the Group to Advance Total Energy (GATE) Information Center (ref. B-3) and was adapted by scaling to the square meter of the local shopping center. The electrical profile of the recreational building (fig. B-2(f)) was also developed from GATE data. Data for the 10-story medium-rise apartment electrical profile (fig. B-2(g)) were obtained from GATE and from data collected for USPO by the engineering consultant firm of Gamze, Dorobkin, Cologen, and Associates, Chicago, Illinois. A medium-rise apartment is located in each village center. The profile for the medium-rise apartment is the same shape as the profile for the high-rise apartment in the community center and was scaled to the proper number of units.

The middle school profile (fig. B-2(h)) and the high school profile (fig. B-2(i)) were developed based on data from a high school in Houston, Texas. The Monday through Friday profiles for the elementary, middle, and high schools are the same and are scaled to the square meter of each building. The Saturday and Sunday profiles are the same for the middle and high schools. These profiles include only domestic loads with no environmental conditioning; therefore, the representative data are valid for all similar buildings in the country. One high school and one middle school are in each village center.

In the CBD, the regional shopping center is the dominant user of electrical power, with a peak of 4000 kilowatts. The profile (fig. B-2(j)) was developed by using data from an earlier USPO study of such a facility. Figure B-2(k) shows the electrical profile of a 12-story office building. Four sets of two such towers are located in the CBD, and the construction of the towers is phased with the growth of the town. The profile was developed by using data from an

office building in Houston, Texas. This profile does not include the electrical load resulting from environmental conditioning, except for the fan coil units.

The CBD contains four 22-story high-rise apartment buildings constructed over the 20-year development cycle. Figure B-2(l) depicts the profile of one apartment building. The profile was developed by combining the necessary data elements from the GATE and the Gamze, Dorobkin, Cologen, and Associates data.

The community college, also in the CBD, has an electrical load profile (fig. B-2(m)) suitable for a daytime schedule with some night classes. Data used for the profile were also from the GATE and the Gamze, Dorobkin, Cologen, and Associates data.

The construction of the inn, or motel, and hotel complex is in two phases. In the first phase, one 75-room low-rise motel and one 200-room high-rise hotel are built. Phase 2 construction consists of one 75-room motel and two 200-room hotels. Figures B-2(n) and B-2(o) show the electrical profile for one 75-room motel and one 200-room hotel, respectively. The loads of the banquet rooms and restaurant are included proportionally in the profiles. The data for the profiles were obtained from the GATE with appropriate scaling for the floor area.

Figure B-2(p) shows the electrical load profile for the community hospital. The profile was developed in an earlier USPO study and includes all loads, such as X-ray, etc., that are expected in a 384-bed community hospital. No environmental conditioning loads for the building are included.

Some electrical loads within the community are not associated with a particular building type. The electrical load for an MIUS is a function of the option considered. Figure B-3 depicts the electrical loads for the water treatment plant and the water distribution system. The total load for three neighborhoods and one village center is the component of the electrical load of the water treatment and distribution equipment of a village center complex in option II. Additional information regarding the development of these data is included in the section entitled "The MIUS Design Options I and II." Also shown in figure B-3 are the distribution loads and the sewage treatment loads for a neighborhood MIUS and a village center in option I. The water treatment, but not the distribution, facility in option I is a central facility for the entire community. The actual motor loads from the water subsystem design were used to calculate the loads in figure B-3.

Houston Lighting and Power Company standards were used for the streetlighting loads of the various sections of the community. The electrical loads for the lighting in the parking areas of the community were based on parking-area lighting levels from McGuiness and Stein (ref. B-4). Figure B-4(a) illustrates the streetlighting loads for a neighborhood, a village center, and a village. The streetlighting and parking-area lighting electrical loads for the town center, or CBD, are shown in figure B-4(b).

Total Electrical Loads and Phasing of Electrical Load Throughout Community Construction

The environmental conditioning of the community (see the section entitled "Heating, Ventilation, and Air-Conditioning Loads") uses excess heat from electrical power generation equipment and from incineration for absorption air-conditioning in the summer. However, it is necessary (as shown in the section on HVAC loads) to provide additional compressive air-conditioning at various times in the summer. The MIUS uses the concept of "floating" air-conditioning; i.e., the absorption/compression split of the total cooling load varies so that the amount of absorption air-conditioning is maximized to use all available heat energy. Therefore, the ratio of absorption and compression changes. The electrical power load is a function of the amount of compressive air-conditioning required.

The MIUS does not directly supply environmental conditioning to the single-family detached houses. Each house has an electrically driven compressive unit that is a standard electrical central air-conditioning unit. The total electrical power load is a result of the amount of compressive air-conditioning required by the MIUS itself and the additional electrical load to air-condition the single-family houses. Additionally, the HVAC auxiliary loads, pump motors, etc., must be included.

All the electrical loads resulting from the HVAC requirements were derived as a function of HVAC loads developed over a 24-hour period. For air-conditioning, the loads are based on a 2-sigma hot summer design day; for winter, the heating loads are based on a 2-sigma cold winter design day. Figure B-5(a) shows the electrical power profile of a neighborhood MIUS of option I, and the village center MIUS power profile is shown in figure B-5(b). This MIUS provides all environmental conditioning through the HVAC system; no single-family homes are serviced by this MIUS. The power profile for the option II village complex MIUS is shown in figure B-5(c). The electrical power profile of the CBD (fig. B-5(d)) is the same for options I

and II. Figure B-5(e) shows the sum of the electrical power load for all elements of the community; the peak power requirement is approximately 250 megawatts.

The growth rate for a neighborhood is different from that of a village center or a CBD. Also, some villages are developed on a 4-year cycle, whereas others are developed on a 3-year cycle. (See table A-9 in appendix A.) Figure B-6(a) shows the electrical load growth for the option I neighborhood MIUS and village center MIUS for the neighborhood development over 3 and 4 years.

The electrical load growth for the option II village complex MIUS, when developed over 3 years and when developed over 4 years, is shown in figure B-6(b). The CBD electrical growth (fig. B-6(c)) is the same for both options. The design case for determining the electrical growth of the community elements is the peak demand, which occurs at 7 p.m. on the design summer day. Figure B-6(d) shows the combined electrical growth of the various community elements over the 20-year development schedule. Also shown (for comparison) is the electrical growth of the same community if electrical power were supplied by conventional means. Detailed information about these conventional systems is given in the main text in the section entitled "Conventional Systems Definition."

Heating, Ventilation, and Air-Conditioning Loads

The calculation of the community heating and air-conditioning loads used basic HVAC load determination techniques from the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) (ref. B-5), (which provides the industry-wide standards and design criteria) supplemented by design manuals from commercial environmental conditioning firms. The actual calculation of the loads on the various building types within the community was performed by a computer program, the Energy Systems Optimization Program (ESOP) (ref. B-6). Washington, D.C., weather data were used for the calculations. The outside temperature used was 309 K (97° F) dry bulb and 300 K (81° F) wet bulb for the summer maximum and 260 K (10° F) dry bulb and 259 K (8° F) wet bulb for the winter low. The design was required to be such that an inside temperature of 296 K (74° F) dry bulb with a 50-percent relative humidity was maintained. For the various apartment buildings within the community, typical Washington, D.C., apartment construction was used as a basis for determining heat transfer coefficients. The five wall types and two roof types shown in figures A-11 and A-12 in appendix A were the basis of building construction. Material "U" factors, solar

factors, and other constraints that were used were obtained from industrially accepted handbooks. Available design heat transfer coefficients were obtained from ASHRAE.

The heating/cooling load profiles were calculated for all the building types within the community. These computer-plotted profiles are shown in figure B-7. The load profiles were plotted for a 24-hour period for the mean-temperature seasonal cases of winter (WI), spring (SP), summer (SU), and fall (FA), with a 47- to 58-percent cloud cover. Also plotted were the 2-sigma low-temperature cases of a winter day with no cloud cover (WI, 2-sigma, cc = 0), a winter day with full cloud cover (WI, 2-sigma, cc = 1), and a 2-sigma high-temperature case of a summer day with no cloud cover (SU, 2-sigma, cc = 0). Figures B-8 and B-9, respectively, illustrate the growth in cooling and space heating that is required over the 20-year development period.

Water Loads

Detailed load analysis of the water management subsystem (WMS) loads were conducted, and the summary is presented in table B-1. The analyses included potable water usage of each facility and the wastewater effluent quantities that are the load on the wastewater treatment system.

The conventional loads for the community potable water supply system were based on an average daily domestic per capita water demand of 0.473 m^3/capita/day (125 gal/capita/day), with an allowance of 100 percent reserve for the maximum water supply demand based on fire protection water requirements.[1] The MIUS loads for potable water were based on the daily water consumption per capita per function per building of 0.378 m^3/capita/day (100 gal/capita/day) as defined for this study with an allowance of 25 percent for peak-day water supply requirements.

The conventional and MIUS loads for the community wastewater treatment system were based on an average daily domestic use per capita of 0.378 m^3/capita/day (100 gal/capita/day) with allowances of 20 percent average for peak flow and infiltration. For the study, the qualities of the influent and the effluent were assumed (refs. B-7 to B-9).

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[1]Preliminary Engineering Report on the Woodlands. Turner, Collie, and Braden, Inc., Consulting Engineers (Houston, Tex.), Dec. 1972.

Figure B-10 shows the community design load growth summary (over the 20-year development period) of the potable water demand and wastewater quantity for a conventional water supply system and for an MIUS.

Solid-Waste Loads

The inhabitants, workers, and visitors in the design community produce 362 Mg/day (399 tons/day) of solid wastes. This quantity of waste must be treated by the MIUS solid-waste management subsystem; if a conventional solid-waste system serviced the town, the waste would have to be removed from the site. Table B-2 is a list of the solid waste loads generated by the various facility types and community components. In option I, the neighborhood MIUS must process 10 904 kg/day (24 038 lb/day) and the village center MIUS must process 8013 kg/day (17 665 lb/day). The village complex MIUS of option II manages 40 710 kg/day (89 749 lb/day) of solid waste. The CBD MIUS, the same in both options, has a solid-waste load of 77 158 kg/day (170 101 lb/day).

The values for residential loads, apartments, townhouses, and single-family dwellings were based on a generation rate of 2.3 kg/capita/day (5 lb/capita/day) (refs. B-10 to B-12). The elementary school solid-waste calculations were based on 4.5 kg/room (10 lb/room) plus 0.11 kg/pupil (0.25 lb/pupil) (data from a commercial source). The school cafeteria wastes are additional and were based on an actual high school in Houston, Texas, used in earlier USPO studies. The college loads are the same as the high school loads. The quantity of solid wastes from an office building was based on 6.13 kg/100 m^2 (1.25 lb/100 ft^2) (ref. B-13). The inn and hotel calculations were based on a solid-waste generation of 1.02 kg/room (2.25 lb/room) plus 0.7 kg/meal (1.5 lb/meal). The amounts are the average of a high-class and a medium-class hotel (ref. B-11). A large amount of solid waste results from the operation of a hospital. The load calculations were based on 13.6 kg/bed (30 lb/bed) plus 0.7 kg/meal (1.5 lb/meal) (ref. B-13). The regional mall and the village center shopping centers both produce 31.18 kilograms of solid wastes per 100 square meters (6.5 pounds per 100 square feet) based on earlier USPO studies.

Figure B-11 illustrates the growth that must be accommodated by the phased construction of the MIUS plants (ref. B-14) over 20 years.

SUBSYSTEMS DESIGN TASKS AND LOGIC FLOW

The design of the subsystems in an MIUS serving the design community is such that an analysis is required of the loads on each subsystem resulting from the buildings being served. An energy analysis of each subsystem then determines the energy consumption within each subsystem. Integration of subsystems enables the determination of the MIUS energy consumption and provides the means of thermally balancing the subsystems so that they work together as efficiently as possible.

Each building must be characterized before the loads analysis can be done. This is a determination of the electrical loads resulting from the building design, the expected use, and the occupancy profile. The construction of each building and the internal heat generation are also determined. From this information, the HVAC and electrical power loads for each building type within each community element can be calculated. After the loads are computed for each building type, they are multiplied by the number of buildings within that type. The loads for all buildings are then summed (for each element of the community) to determine the total HVAC and electrical power loads for an MIUS.

To perform an energy analysis, a characterization of the various subsystems necessary to service a particular building type is required. For the HVAC, power generation, solid-waste treatment, and domestic hot water subsystems, a determination is required of the equipment necessary to accomplish the tasks for the respective subsystems and to meet the load demands. After the initial equipment selection is made, the energy consumption of the integrated MIUS is calculated. The various subsystem designs are iterated so that they are thermally balanced within the MIUS. Primary consideration is given to prime mover and boiler consumption, amount and type of air-conditioning and heating, total electrical power load, amount of recoverable heat and the utilization of that recovered heat, unused recovered heat, and heat rejection requirements.

The following list details the input data necessary to perform the load analysis.

1. Building type characterization
    a. U-values for walls, roof, and glass
    b. Areas of walls, roof, and glass
    c. Glass type factor (for solar admittance into building)
    d. Occupancy profile

2. Domestic and auxiliary electricity profile
   a. Window shade factor
   b. Ventilation rates
   c. Design inside temperature profile
   d. Equivalent temperature differential profiles for walls and roof

3. Environmental conditions
   a. Hourly profile of outside dry bulb temperature
   b. Direct solar radiation profile
   c. Profile of window heat gain from convection and radiation
   d. Equivalent temperature differential profiles for walls and roof
   e. Profile of enthalpy for inside and outside air

The input data necessary to perform the energy analysis are as follows.

1. Solid-waste data
   a. Solid-waste contents and amount
   b. Heat value of solid waste
   c. Fuel requirements
   d. Disposal method (incinerator and/or pyrolysis)
   e. Waste-heat utilization profile
   f. Heat recovery efficiency
   g. Operation cost factors

2. HVAC data
   a. Boiler efficiency
   b. Absorption/compression split ratio
   c. Coefficient of performance (COP) profiles for absorption and compression chillers
   d. Heat rejection water requirements

3. Electrical power generation
   a. Generator rated capacity
   b. Engine rated capacity
   c. Fuel heating values
   d. Fuel as opposed to load curves
   e. Waste heat as opposed to load curves (for oil coolers, water jacket, and exhaust jacket)
   f. Steam cycle data, if required

4. Water and energy uses
   a. Uses for excess 389-K (240° F) heat
   b. Uses for excess 350-K (170° F) heat
   c. Uses for excess 311-K (100° F) heat
   d. Uses for wastewater effluent

The following is a list of the output data from the loads analysis.

1. Hourly heat gain from walls, roof, windows, ventilation, hot water, electricity, etc.

2. Total hourly space-heating demand

3. Total hourly air-conditioning demand

4. Power requirements

5. Hot water requirements

6. Totals of above data for entire element served by MIUS

7. Heat rejection water utilization

8. Wastewater requirements not met

9. Wastewater available for reuse

10. Solid waste, disposal costs, and effluent

11. Seasonal and yearly fuel consumption

12. Comparison of 24 MIUS configurations and 1 conventional system

The output data from the energy analysis are as follows.

1. Generator data: Engine output, fuel consumption, thermal efficiency, generator output, etc.

2. Number of generators required

3. Waste heat available and its sources

4. Boiler heat and fuel

5. Amount of absorption and compression air-conditioning

6. Waste heat not used at each of three temperature levels

7. Waste heat utilized at three levels

8. Waste heat requirements not met

THE MIUS DESIGN OPTIONS I AND II

Two design options were considered for servicing the community; and both options are accommodative. Option I consists of three different types of MIUS plants: the CBD MIUS, the village center MIUS, and the neighborhood MIUS. Design option II consists of two types of MIUS plants serving the community: the CBD MIUS and the village complex MIUS.

The CBD MIUS

The CBD MIUS is designed to provide all the service requirements for the CBD (fig. B-12). The MIUS systems in the CBD are the same for options I and II, except that the CBD MIUS in option II treats and provides potable water to the CBD instead of having a central water treatment facility serving the entire community. Figure B-13 is a schematic of the CBD MIUS.

The power generation system consists of ten 4415-kilowatt diesel generators with both low-grade and high-grade thermal extraction systems (fig. B-14). The low-grade thermal energy is taken from the intercooler, lubrication oil cooler, and water jacket cooler and supplemented by the high-grade thermal energy to provide 366-K (200° F) water for space heating and domestic hot water. This water is piped to all buildings in the CBD.

The high-grade thermal energy is generated by low-pressure steam heat recovery units on the exhaust of each prime mover. This steam header is also tied into the heat-recovery system of the incinerators. Seven 1361-kg/hr (3000 lb/hr) incinerators are used in this MIUS to handle all the trash from the CBD. This low-pressure steam drives the five absorption chillers used in the HVAC system (fig. B-15).

A chilled-water distribution loop is routed to all the CBD buildings to satisfy the air-conditioning requirements. The chilled water is generated by five 5838-kilowatt (1660 ton) absorption chillers and five 6682-kilowatt (1900 ton) electrically driven compression chillers. Rather than using a cooling tower for extracting the heat from the chiller condenser water, a 115.3-hectare (285 acre) lake is used. The lake cools the condenser water and also provides the necessary water to satisfy the CBD firefighting requirements.

Sewage treatment consists of a conventional biological system designed for a 6341-m^3/day (1.675 x 10^6 gal/day) capacity. The wastewater treatment plant schematic is shown

in figure B-16. The processes used in the system are sedimentation, biological nitrification/denitrification, clarification, coagulation/flocculation, disinfection, and carbon absorption with carbon regeneration. Sludge conditioning is performed by using a gravity thickener, a vacuum filter, and an incinerator; the ultimate ash disposal is a landfill.

Solid waste is disposed of by incineration and energy is recovered by heat recovery as described previously. The collection process in the CBD is depicted in figure B-17.

In the option II CBD MIUS, the potable water is treated by using coagulation/flocculation, clarification, mixed media filter, and disinfection. In option I, the required 6341 m^3/day (1.675 x 10^6 gal/day) is piped in from a central potable water treatment facility on the periphery of the community that treats 51 860 m^3/day (13.7 x 10^6 gal/day) using the same processes. Figure B-18 is a schematic of this process.

The potable water supply is obtained from a surface source 24 kilometers (15 miles) away and is delivered to the community by pipe. Water treatment in option I is at the CBD MIUS and the water is distributed to the community as shown in figure B-19. In option II, the water is treated at each MIUS plant.

The treated wastewater is stored in the lake for the fire demand supply source, irrigation, and HVAC use. Fire demand distribution is accomplished by separate piping. The use of this method of supplying water for firefighting reduces the size of the potable water pipes. Wastewater is delivered to the MIUS by a gravity flow system. The treatment occurs within each MIUS, thus eliminating trunk and interceptor lines.

Cooling, by chilled water, is distributed to the various facilities by two pipes in a four-pipe system. The flow rate within the pipes is 3 m/sec (10 ft/sec). The pipes have standard insulation with an exposure of 305 K (90° F), 80-percent humidity, and a change in temperature, delta-T, of 6.7 K (12° F). Heating, by hot water, is distributed through the other two pipes at a flow rate of 3 m/sec (10 ft/sec). The heating pipes have an exposure of 261 K (10° F), and a delta-T of 11 K (20° F).

Electrical power is distributed to each building by primary feeders that are direct-burial, copper insulated conductors with a transmission voltage of 13.8 kilovolts and are three-phase wye connected.

The distribution of all services within the CBD is shown in figure B-20. The distribution of the community utilities for both design options is accomplished by two types of common trenches. The piping for the fire-protection water and sewer is placed in one trench, and the potable water and HVAC piping is placed in a second trench (fig. B-21).

Village Center MIUS

The village center MIUS is designed to provide some of the service requirements for the village center (fig. B-22). A schematic of the village center MIUS is shown in figure B-23. The power generation system consists of four 1750-kilowatt diesel generators, and the system is the same as the option I CBD MIUS.

Solid waste disposal is accomplished by four 1360-kg/hr (3000 lb/hr) incinerators that manage all the trash from the village center.

The chilled water distribution loop works in the same manner as the one for the CBD MIUS, except that there are three 3956-kilowatt (1125 ton) absorption chillers and three 2690-kilowatt (765 ton) electrically driven compression chillers. A dual-purpose pond, 110 by 49 meters (360 by 162 feet), is used for extracting heat from the chiller condenser water and for firefighting requirements.

Sewage treatment consists of a conventional biological system designed for a 1703-m^3/day (450 000 gal/day) capacity. The sewage treatment process is the same as that for the CBD MIUS.

The 1703 m^3/day (450 000 gal/day) for the village center is satisfied by piping it in from the central potable water treatment facility. The method used in collecting solid waste for incineration is shown in figure B-24. Distribution of utilities to the buildings is by common trenching as in the CBD MIUS (fig. B-25).

Neighborhood MIUS

The neighborhood MIUS is designed to provide some of the service requirements for the neighborhood (fig. B-26). A schematic of the neighborhood MIUS is shown in figure B-27.

The power generation system consists of five 1750-kilowatt diesel generators in 17 of the MIUS's and four 1750-kilowatt units in the remaining four MIUS's. This configuration enables power to be transferred throughout the

community on an electrical grid. In other respects, the power generation system is the same as that in the CBD MIUS. The water provided by the thermal extraction system is piped only to the higher density area of the neighborhood, because the single-family detached buildings are all-electric.

The high-grade thermal energy is generated by low-pressure steam heat recovery units on the exhaust of each prime mover. This low-pressure steam drives the absorption chiller that is used in the HVAC system. There is no incineration in the neighborhood to supplement the high-grade thermal energy because the trash is exported to the village center MIUS for incineration.

A chilled water distribution loop is routed to the buildings in the higher density area of the neighborhood to satisfy the air-conditioning requirements. The chilled water is generated by a 2595-kilowatt (738 ton) absorption chiller and a 2884-kilowatt (820 ton) electrically driven compression chiller. A pond that is 46 by 30 meters (150 by 100 feet) is used for extracting the heat from the chiller condenser water.

As in the CBD MIUS, sewage treatment is by a conventional biological system. The neighborhood MIUS sewage treatment system is designed for a 1703-m^3/day (450 000 gal/day) capacity.

The 1703-m^3/day (450 000 gal/day) potable water requirement for the neighborhood is satisfied by piping water from the central potable water treatment facility.

Utilities distribution is by common trenching. Figure B-25 shows the neighborhood distribution system.

Village Complex MIUS

The option II village complex MIUS is designed to provide all the service requirements for the village center and three adjacent neighborhoods (fig. B-28). Figure B-29 is a schematic of the village complex MIUS.

The power generation system consists of eight 4415-kilowatt diesel generators and is the same as that for the CBD MIUS. Water is piped to the buildings in the village center and the higher density area of the neighborhood because the single-family detached buildings are all-electric. Four 1360-kg/hr (3000 lb/hr) incinerators manage all the trash from the village center and three adjoining neighborhoods.

A chilled water distribution loop is routed to all the village center buildings as well as the higher density areas of the neighborhoods to satisfy the air-conditioning requirements. The chilled water is generated by four 4843-kilowatt (1377 ton) absorption chillers and four 3774-kilowatt (1073 ton) electrically driven compression chillers. A pond that is 110 by 49 meters (360 by 162 feet) is used to extract heat from the chiller condenser water.

Sewage treatment is accomplished by a conventional biological system designed for a 6341-m^3/day (1.675×10^6 gal/day) capacity and is identical to that of the CBD MIUS. Potable water is treated by coagulation/flocculation, clarification, mixed media filter, and disinfection. This system has the same capacity as the sewage system; that is, 6341 m^3/day (1.675×10^6 gal/day).

The distribution of the utility services is by the common trenching method described earlier. Figure B-30 is a diagram of the distribution system for a typical village complex MIUS. Because the water is treated at each MIUS plant, the raw water must be brought into the community and distributed to each MIUS plant. Figure B-31 depicts the water source distribution. The distribution equipment for the CBD, neighborhood, village center, and village complex MIUS's is given in table B-3.

COMMUNITY FUEL SUPPLY

The basic fuel for the MIUS plants is number 2 diesel fuel oil. The fuel is delivered to the community vicinity by rail tank car, and a 10-day supply is stored at a tank farm adjacent to the community. Fuel is transported to each MIUS installation through an underground pipeline system (fig. B-32). In both options, a day's supply of fuel oil is stored in tanks located at the CBD and the village center.

GROWTH DESCRIPTION

To illustrate the means for handling the growth of a community segment, a village complex built over a 4-year period is used. This example illustrates the typical installation schedule for the equipment within the particular MIUS facility. The installation schedule for air-conditioning, power generation, and solid-waste incineration is shown in figure B-33. This type of schedule is implemented for each MIUS facility throughout the growth of the community over the full 20-year development period.

MONITOR AND CONTROL SYSTEM

The instrumentation, control-room equipment, and operational philosophy for the community MIUS control and monitoring system have been determined from a detailed analysis of baseline subsystems. In earlier studies, a general baseline set of subsystems was used to configure a typical MIUS installation control and monitoring system. The typical subsystems were as follows.

1. Power generation - diesel engines
2. Solid waste - incineration
3. Liquid waste - physical/chemical
4. Water treatment - physical/chemical
5. Air-conditioning - absorption/compression
6. Heating - water/steam

The instrumentation for determining the operational integrity of each of these pieces of equipment was defined. A control-room operational philosophy was developed, and the total hardware costs were determined for a set of the subsystems in a particular configuration, which included the following items.

1. Four diesel engines/generators
2. Two absorption chillers
3. One centrifugal chiller
4. One liquid-waste treatment subsystem
5. One freshwater treatment subsystem
6. One incinerator (controls primarily on heat exchanger)

The results of this analysis are documented in reference B-15.

SYSTEM EXTRAPOLATION TO COMMUNITY MIUS CONFIGURATION

In applying the results of the previous analysis to those subsystems selected for the community MIUS, it was

first necessary to determine major differences in the subsystems. No major differences were evident but the following two very minor discrepancies were found.

1. Discrepancy - The community liquid-waste treatment system is a biological one with a tertiary physical/chemical system.

Disposition - The biodigester ahead of the physical/chemical system control and monitoring equipment is an insignificant consideration. The biodigester treatment does not affect these control and monitoring techniques.

2. Discrepancy - The community MIUS heating and cooling system uses cooling ponds for heat removal instead of cooling towers.

Disposition - Monitoring of concentration of dissolved solids in cooling towers was the primary control function. This same function is also directly applicable to the cooling pond.

These two items, in addition to the more extensive grid interconnects for electrical power, fuel, and water distribution that are required for the community MIUS, constitute the changes to the baseline design.

In summary, the instrumentation requirements are based on automatic control of those functions within the subsystems that are required to shut off valves, divert flow, add chemicals, increase steam output, maintain load balancing, etc. When the function can be accomplished irrespective of routine operator intervention, local pneumatic-type controls are used. These controls are commonly a portion of the subsystem in less complex installations. Parameters that indicate the status of these local controllers are available in the control station.

The automatic controller is installed in the control center for those functions that the operator periodically adjusts to maintain the control within certain limits. The control actuation and alarm outputs are automatically initiated by the controller as the monitored signals vary about the tolerance levels. A digital supervisory system has been included in each community MIUS installation and serves as the overall status monitor of the operations. The computer that accomplishes these functions is a general-purpose minicomputer of 16-bit word size. An internal core memory of 16 000 bytes is required for storage of active programs. This memory is supplemented by a magnetic tape (cassette) for storage of processed data, such as significant changes in status and appropriate switching action that was required. The data from the subsystems

sensors and transducers are digitized at the control center and made available to the minicomputer input data channels. Output commands to the relay-controlled switchgear and to controllers for set-point change are transmitted by the minicomputer output channels. An interactive display (cathode-ray tube and keyboard) enables the operator to call up various functional tests and operations-monitoring routines for display so that the detailed performance of a given area of the MIUS can be evaluated. This computer also uses a teletype printer keyboard that enables it to serve as a logging device to record all significant change data. Prestored limits within the computer provide for comparison of incoming data with expected values. The controller set point and output signal can be readjusted by the computer system either automatically or under operator control. A record of the automatic operations is printed for the operator log.

Each MIUS control system will contain an interface to a central control station for the community project. On receipt of the data from a remote station, the central station will alert "floating" maintenance crews of problems or impending problems during the night shifts. When the operator reports in for his routine, he will have the printed log for a daily report containing the summary of the activities of the previous night. The major function of the operator will be to file the report with the central station where bookkeeping, logistics management, and maintenance (both preventive and corrective) are performed and scheduled.

This central control station is a separate control room that interfaces with all MIUS stations by communications lines (telephone). For commonality of approach, each station will provide the same type of information and expect similar services from the central station. The central station has been sized to accommodate resource allocation where feasible. Power distribution is the primary function that can be interconnected in a community grid network under control of the central station. If the installed capacity cannot meet the load, the central station will determine whether or not there is excess capacity at another station and will perform switching to meet the load requirements of the disabled station. The equipment in the central station is centered around a general-purpose digital computer system of 32 000-byte memory storage of 18-bit words. The programs and parameter data are stored on three mass storage disks, each having a 2.2 million-word capacity. There are four tape units and one card/reader/punch. A 1000-line/min printer is required for the report and billing outputs. Communication multiplexers interface the MIUS control centers by telephone lines.

In addition to operational control, the central station will perform the data-processing jobs (such as billing and payroll) that are a necessary part of utilities management. The complement of equipment that is necessary to do this job will not be taxed on a 100-percent basis. More than 50 percent of the system time is expected to be available for other functions that are inherent in municipal management, such as tax computation for cities and schools. Revenues for this type of function will be realized because typically they are computerized by separate rental/purchase arrangements.

Table B-4 summarizes the monitoring and control equipment for the CBD MIUS, the option I village center MIUS, the option I neighborhood MIUS, and the option II village complex MIUS at one-third of the final configuration (the end of the 20-year development).

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TABLE B-1.- COMMUNITY LOADS SUMMARY FOR THE WMS

Facility	Unit loads m^3/capita/day (gal/capita/day)	Total wastewater flow, m^3/day (gal/day)	Total hot water, m^3/day (gal/day)
Neighborhood			
Single-family homes[1]	0.24 (64)	688 (181 815)	310 (81 995)
Townhouse[1]	.24 (64)	314 (82 944)	144 (37 921)
Garden apartment[1]	.24 (64)	147 (38 782)	67 (17 756)
Elementary school[2]	.076 (20)	30 (7 800)	5 (1 240)
Total		1179 (311 341)	526 (138 912)
Village center			
High-rise apartment[1]	.23 (60)	264 (69 828)	117 (30 795)
High school[2]	.10 (25)	131 (34 508)	31 (8 282)
Middle school[2]	.10 (25)	131 (34 508)	31 (8 282)
Office building[3]	.10 (25)	189 (50 000)	12 (3 150)
Local shopping center[3]	[4].004 (.1)	28 (7 503)	2 (472)
Recreation center[2]	.04 (10)	8 (2 000)	4 (1 120)
Total		751 (198 347)	197 (52 101)
Town center			
High-rise apartment[1]	.23 (60)	352 (93 104)	155 (41 060)
College[2]	.06 (15)	134 (35 325)	2 (494)
Hospital[5]	[6].76 (200)	285 (75 337)	111 (29 380)
Inn[2]	[6].15 (40)	695 (183 600)	269 (71 022)
Office building[3]	.09 (25)	757 (200 000)	48 (12 600)
Shopping mall[3]	[4].004 (.1)	993 (262 278)	82 (21 708)
Total		3216 (849 644)	667 (176 294)

[1]Reference B-7.
[2]Reference B-8.
[3]Reference B-9.
[4]m^3/day/m^2 (gal/day/ft^2).
[5]Personal communication, Pollutrol Technology, Inc. (Portland, Maine), 1973.
[6]m^3/day/bed (gal/day/bed).

TABLE B-2.- COMMUNITY SOLID-WASTE LOADS

Facility	Load, kg/day (lb/day)
Neighborhoods	
Single-family dwelling	6 468 (14 260)
Townhouses	2 939 (6 480)
Garden apartments	1 396 (3 078)
Schools	100 (220)
Total	10 903 (24 038)
Total for 21 neighborhoods	228 976 (504 798)
Village centers	
High-rise apartments	2 722 (6 000)
Schools	596 (1 313)
Office buildings	2 139 (4 716)
Shopping centers	2 556 (5 636)
Total	8 013 (17 665)
Total for 7 village centers	56 090 (123 655)
Town center	
College	602 (1 328)
Mall	55 977 (123 408)
Inn	2 126 (4 688)
Hospital	6 269 (13 820)
High-rise apartments	3 629 (8 000)
Office buildings	8 553 (18 857)
Total	77 156 (170 101)
Total	362 229 (798 564)

TABLE B-3.- DISTRIBUTION SUMMARY

(a) Electrical and HVAC subsystems

Parameter	CBD	Village center	Neighborhood	Village complex
Electrical (2-sigma) design				
Distribution type	Wye	Wye	Wye	Wye
Voltage, kV	3.18	3.18	3.18	3.18
Wire size (copper)				
Phase conductor	600 MCM	350 MCM	500 MCM	500 MCM
Neutral	1/0	1/0	4/0	1/0
Wire length, m (ft)				
Phase conductor	16 916 (55 500)	4267 (14 000)	31 135 (102 150)	97 704 (320 550)
Neutral	5639 (18 500)	1433 (4700)	10 378 (34 050)	32 568 (106 850)
Transformer size, kW	4000	80	80	80
No. of transformers	9	81	107	395
Switchgear size, kW	800	800	80	800
No. of switchgears	45	8	11	40
kW/feeder	8953	6477	8529	7896
No. of feeders	4	1	1	4
Average power factor	0.9	0.9	0.9	0.9
Feeder service	Underground	Underground	Underground	Underground
HVAC				
Configuration	Three-loop, four-pipe	One-loop, four-pipe	One-loop, four-pipe	Four-loop, four-pipe
Loop 1				
Length of each pipe, m (ft)	1768 (5800)	1509 (4950)	1753 (5750)	2530 (8300)
Diameter of cooling pipes, cm (in.)	51 (20)	51 (20)	30 (12)	30 (12)
Diameter of heating pipes, cm (in.)	31 (12)	20 (8)	30 (12)	20 (8)
Loop 2				
Length of each pipe, m (ft)	1951 (6400)	- -	- -	3216 (10 550)
Diameter of cooling pipes, cm (in.)	61 (24)	- -	- -	31 (12)
Diameter of heating pipes, cm (in.)	20 (8)	- -	- -	20 (8)
Loop 3				
Length of each pipe, m (ft)	2637 (8650)	- -	- -	2941 (9650)
Diameter of cooling pipes, cm (in.)	61 (24)	- -	- -	31 (12)
Diameter of heating pipes, cm (in.)	31 (12)	- -	- -	20 (8)

TABLE B-3.- Concluded

(a) Electrical and HVAC subsystems - Concluded

Parameter	CBD	Village center	Neighborhood	Village complex
Loop 4				
Length of each pipe, m (ft)	- -	- -	- -	1417 (4650)
Diameter of cooling pipes, cm (in.)	- -	- -	- -	51 (20)
Diameter of heating pipes, cm (in.)	- -	- -	- -	25 (10)

(b) Fire, potable water, and wastewater subsystems

Parameter	CBD	Village center	Neighborhood	Village complex
Fire system				
Length of pipes, m (ft)				
6-in. diam.	- -	183 (600)	6614 (21 700)	20 696 (67 900)
8-in. diam.	594 (1950)	884 (2900)	1768 (5800)	4 679 (15 350)
10-in. diam.	- -	- -	2134 (7000)	10 211 (33 500)
12-in. diam.	1097 (3600)	472 (1550)	- -	290 (950)
14-in. diam.	- -	- -	- -	213 (700)
16-in. diam.	2149 (7050)	- -	- -	- -
Potable water supply				
Length, m (ft)				
1.5-in. diam.	- -	- -	46 (150)	305 (1000)
2-in. diam.	- -	107 (350)	305 (1000)	1204 (3950)
3-in. diam.	152 (500)	183 (600)	7544 (24 750)	21 412 (70 250)
4-in. diam.	122 (400)	- -	- -	- -
6-in. diam.	823 (2700)	777 (2550)	2592 (8500)	6721 (22 050)
8-in. diam.	640 (2100)	335 (1100)	732 (2400)	3871 (12 700)
12-in. diam.	1082 (3550)	- -	- -	1204 (3950)
14-in. diam.	945 (3100)	- -	- -	- -
16-in. diam.	- -	- -	- -	305 (1000)
Wastewater				
Length, m (ft)				
6-in. diam.	- -	122 (400)	- -	- -
8-in. diam.	1250 (4100)	1402 (4600)	9434 (30 950)	29 337 (96 250)
10-in. diam.	229 (750)	- -	11 125 (36 500)	381 (1250)
12-in. diam.	320 (1050)	305 (1000)	- -	- -
15-in. diam.	945 (3100)	- -	- -	1021 (3350)
18-in. diam.	975 (3200)	- -	- -	335 (1100)
21-in. diam.	- -	- -	- -	274 (900)
24-in. diam.	- -	- -	- -	472 (1550)

TABLE B-4.- SUMMARY OF THE MIUS MONITORING AND CONTROL SYSTEM AT ONE-THIRD GROWTH

(a) The CBD

Subsystem	Central controls and instrumentation				Supervisory and interface equipment	
	Factors measured	No. of units	Cost/unit	Total cost	Description	Cost
Power generation (diesels)	Flows, temperature, pressure, level	3	$11 800	$35 400	Digital supervisory control system (computer, memory, display, printer, tape, etc.)	$50 000
Power generation (generators)	Temperature, vibration	3	3 440	10 320	Data input/output for all subsystems signals and interfacing instrumentation	50 000
HVAC absorption chiller	Flows, temperature, pressure, level	3	13 760	41 280	Interfacing instrumentation, flows, pressure, temperature, distribution lines, etc.	35 000
HVAC centrifugal chiller	Flows, temperature, pressure	3	11 935	35 805	Control room installation, panel board	7 000
Liquid waste	Flows, temperature, pressure, special analyzers	1	41 370	41 370	Software application	55 000
Water treatment	Flows, temperature, pressure, special analyzers	1	15 970	15 970	Not applicable	
Incinerator	Heat exchanger, flow, temperature, pressure, fuel flow	5	3 000	15 000	Not applicable	
Total				$195 145		$197 000
Total subsystem cost						$392 145

TABLE B-4.- Continued

(b) Option I village center

Subsystem	Central controls and instrumentation				Supervisory and interface equipment	
	Factors measured	No. of units	Cost/unit	Total cost	Description	Cost
Power generation (diesels)	Flows, temperature, pressure, level	4	$11 800	$47 200	Digital supervisory control system (computer memory, display, printer, tape, etc.)	$50 000
Power generation (generators)	Temperature, vibration, volt (power supplied with generator)	4	3 440	13 760	Data input/output for all of subsystems signals and interfacing instrumentation	50 000
HVAC absorption chillers	Flows, temperature, pressure, level	4	13 760	55 040	Interfacing instrumentation (flows, pressure, temperature, for distribution lines, etc.)	35 000
HVAC centrifugal chillers	Flows, temperature, pressure	4	11 935	47 740	Control room installation panel/board	11 000
Liquid waste, physical/chemical	Flows, temperature, pressure load, special analyzers	1	41 370	41 370	Software (applications)	55 000
Incinerator	Heat exchanger, flows, temperature, pressure, fuel control	4	3 000	12 000	Not applicable	———
Total				$217 110		$201 000
Total subsystem cost						$418 110

TABLE B-4.- Continued

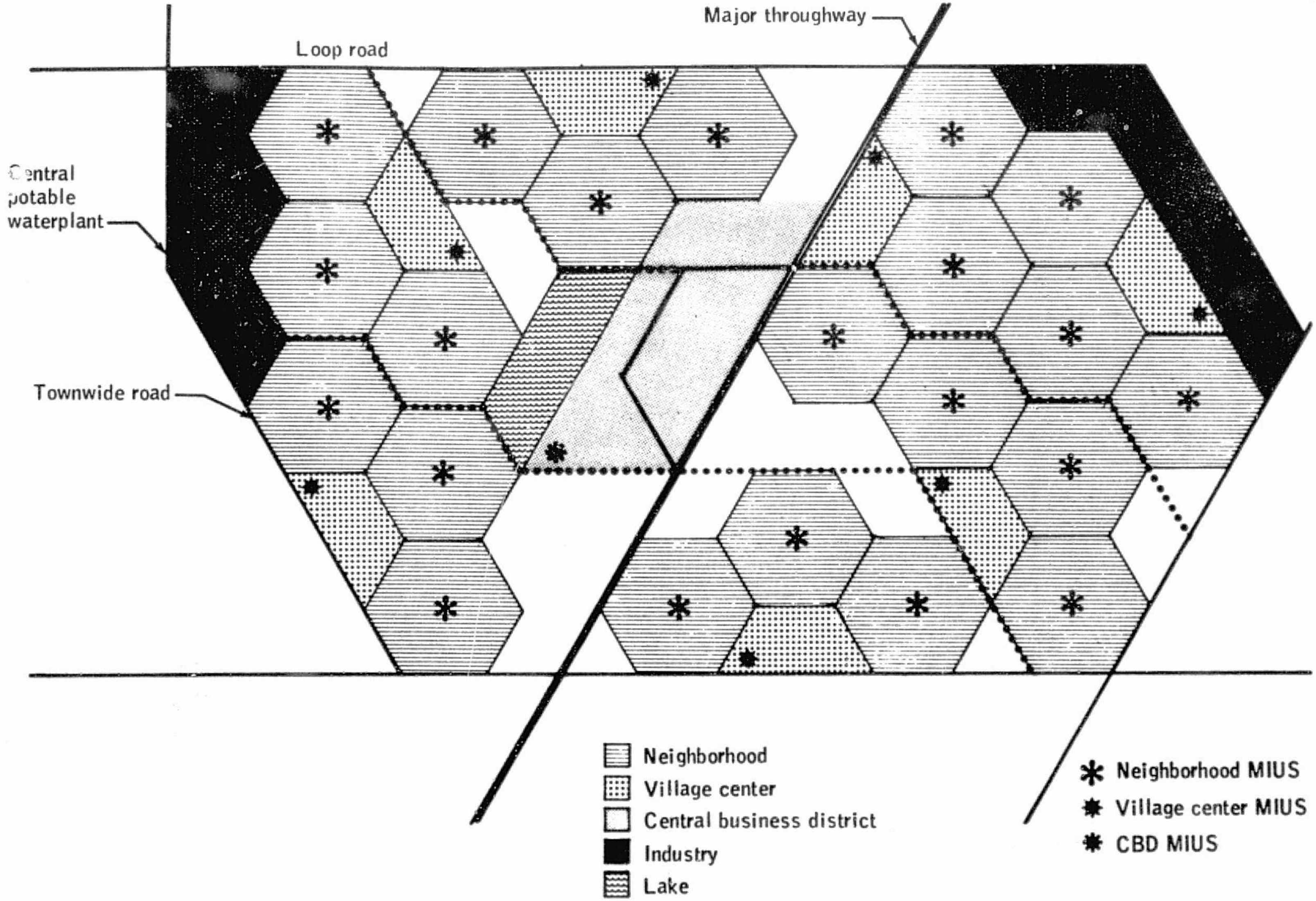
(c) Option I neighborhood

Subsystem	Central controls and instrumentation				Supervisory and interface equipment	
	Factors measured	No. of units	Cost/unit	Total cost	Description	Cost
Power generation (diesels)	Flows, temperature, pressure, level	5	$11 800	$59 000	Digital supervisor control system (computer, memory, display, printer, teletype, tape, terminal panels)	$50 000
Power generation (generators)	Temperature, vibration (voltage power supplied by vendor)	5	3 440	17 200	Data input/output for subsystem signals and interfacing instrumentation	50 000
HVAC absorption chillers	Flows, temperature, pressure, level	1	13 760	13 760	Interfacing instrumentation (flows, pressure, temperature) on distribution pipelines etc.	30 000
HVAC centrifugal chillers	Flows, temperature, pressure	1	11 935	11 935	Control room installation (panel)	8 000
Liquid waste, physical/chemical	Flows, temperature, pressure, load, special analyzers (includes cooling-tower water)	1	41 370	41 370	Software (applications)	55 000
Total				$143 265		$193 000
Total subsystem cost						$336 265

TABLE B-4.- Concluded

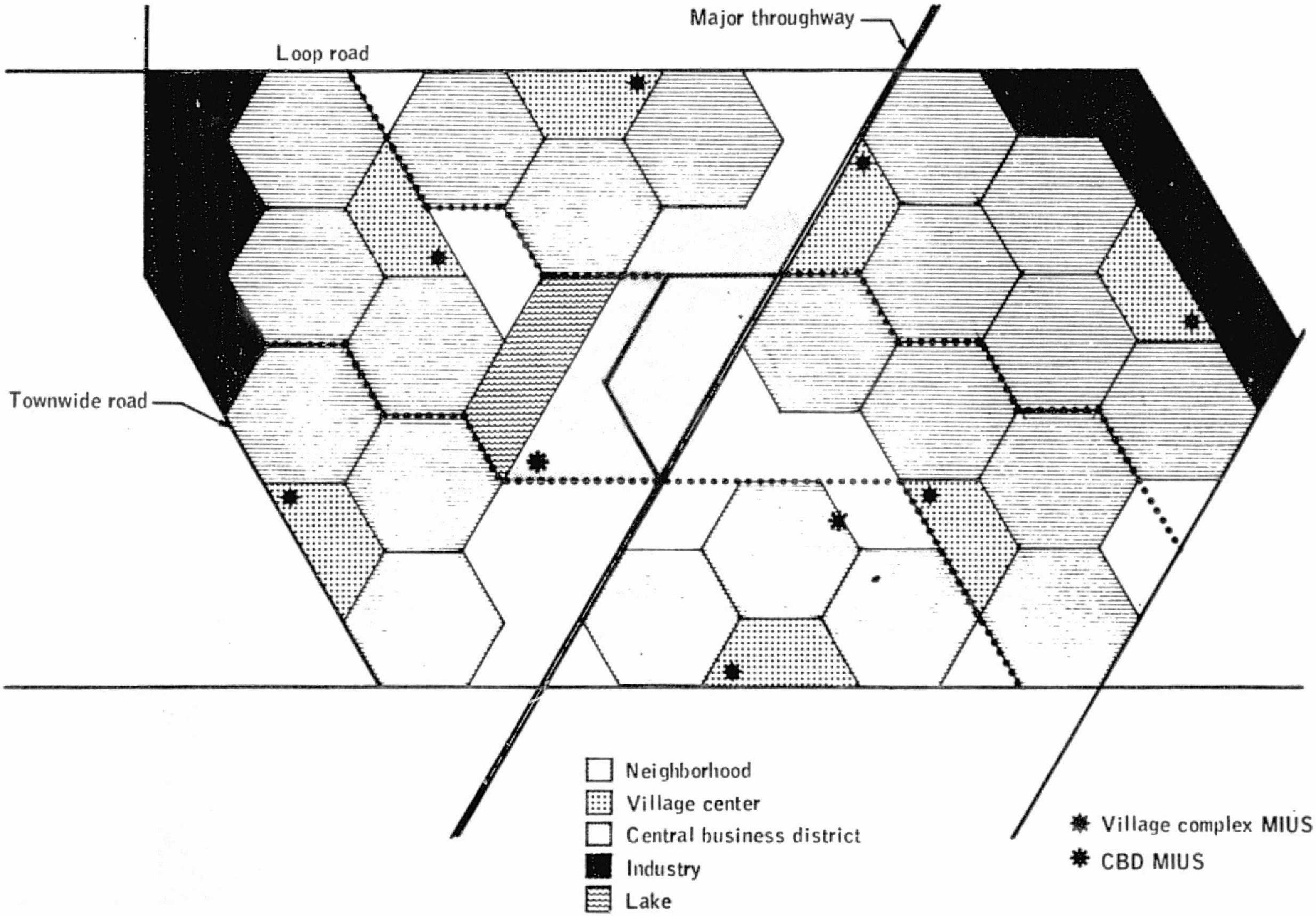
(d) Option II village complex

Subsystem	Central controls and instrumentation				Supervisory and interface equipment	
	Factors measured	No. of units	Cost/unit	Total cost	Description	Cost
Power generation (diesel)	Flows, temperature, pressure, level	8	$11 800	$94 400	Digital supervisory controls system (computer memory, display, printer, teletype, tape, terminals)	$50 000
Generators	Temperature, vibration	8	3 440	27 520	Data input/output for subsystem signals and interfacing instrumentation	80 000
HVAC absorption chillers	Flows, temperature, pressure, level	4	13 760	55 040	Interfacing instrumentation (flows, pressure, temperature) on distribution pipelines, etc.	60 000
HVAC centrifugal chillers	Flows, temperature, pressure	4	11 935	47 740	Control room installation panel board	20 000
Liquid waste	Flows, temperature, pressure, load, special analyzers	1	41 370	41 370	Software application	55 000
Incinerator	Heat exchanger, flows, temperature, pressure, fuel flow	4	3 000	12 000	Not applicable	
Water	Flows, temperature, pressure, special analyzers	1	15 970	15 970	Not applicable	
Total				$294 040		$265 000
Total subsystem cost						$559 040



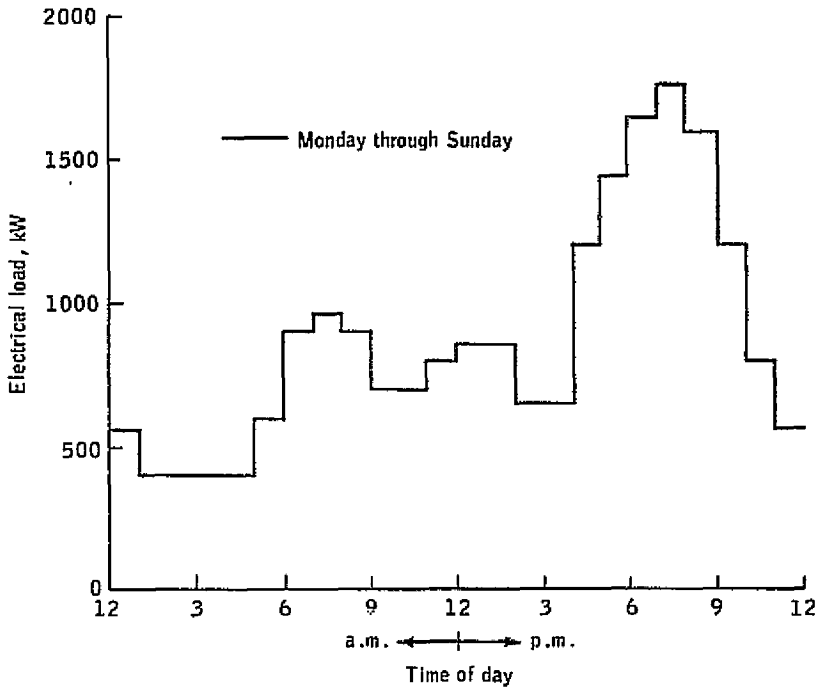
(a) Option I.

Figure B-1.- New community for MIUS.

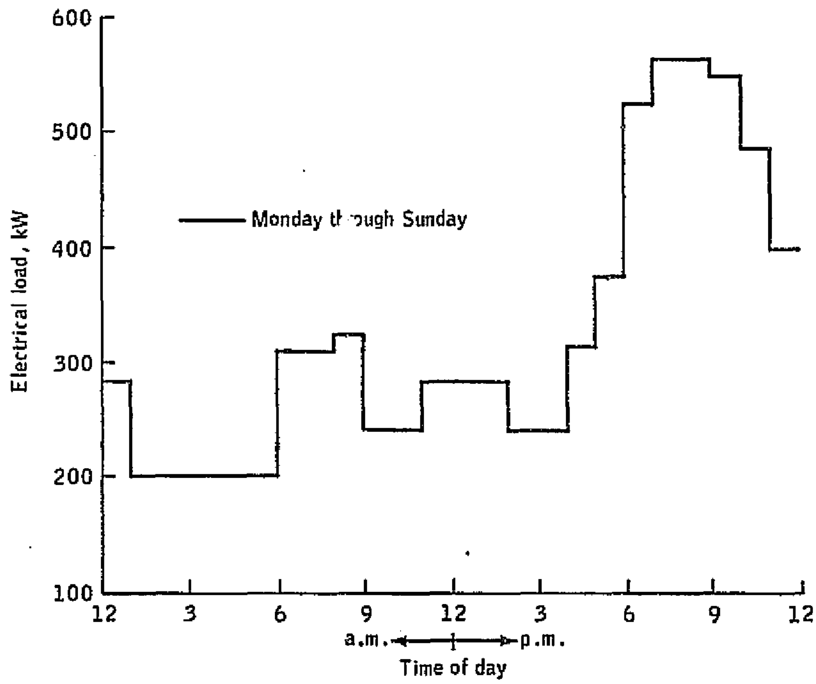


(b) Option II.

Figure B-1.- Concluded.

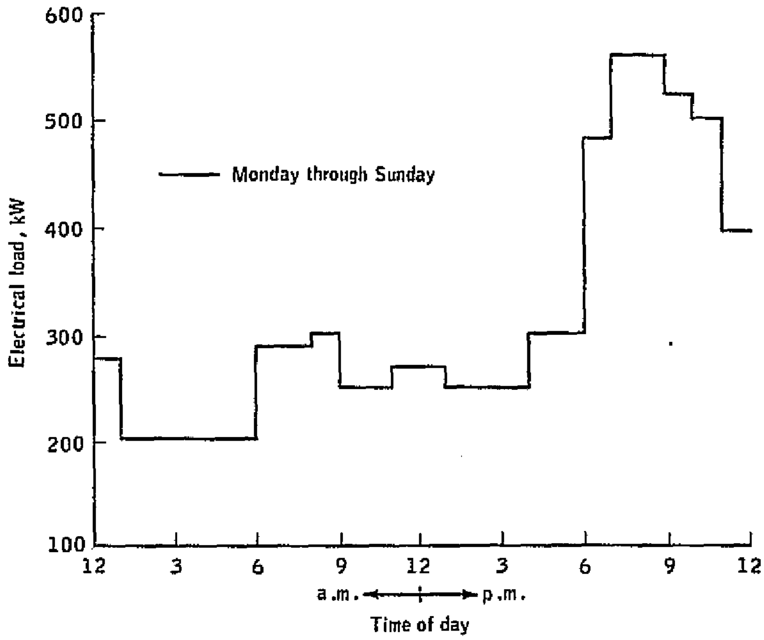


(a) 713 single-family dwellings.

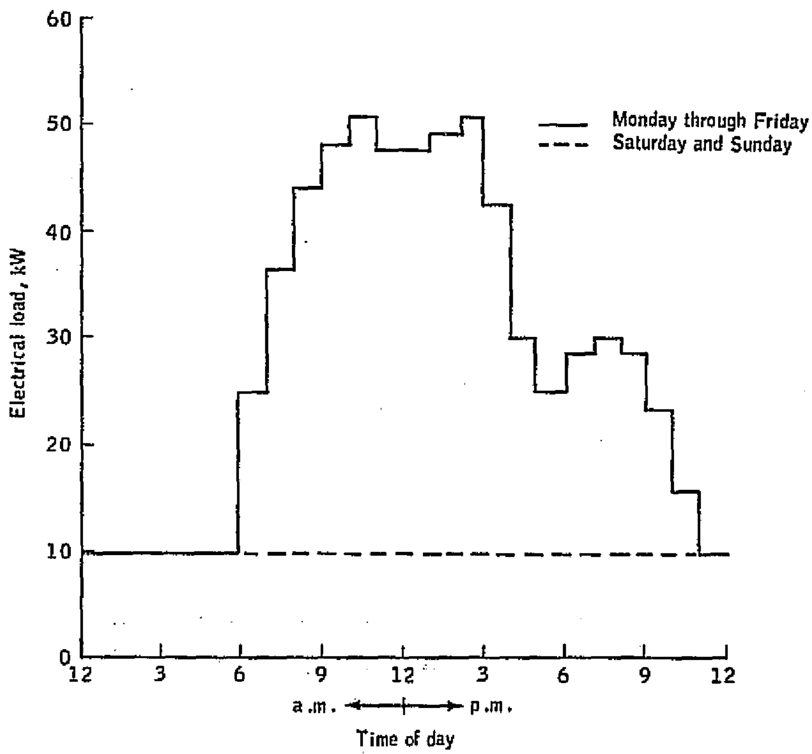


(b) 324 townhouses.

Figure B-2.- Community electrical-load profiles (domestic loads only).

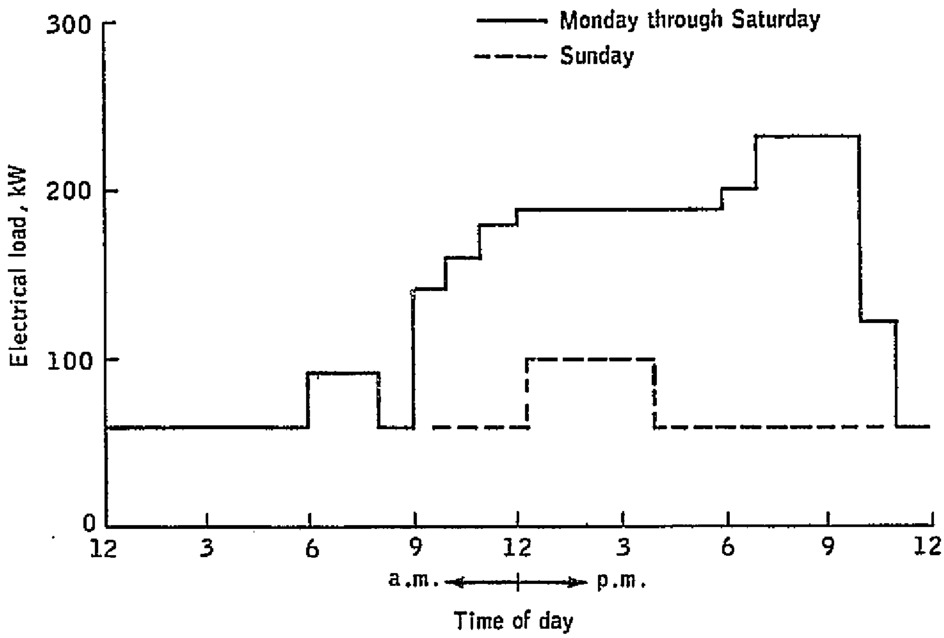


(c) 324 garden apartments.

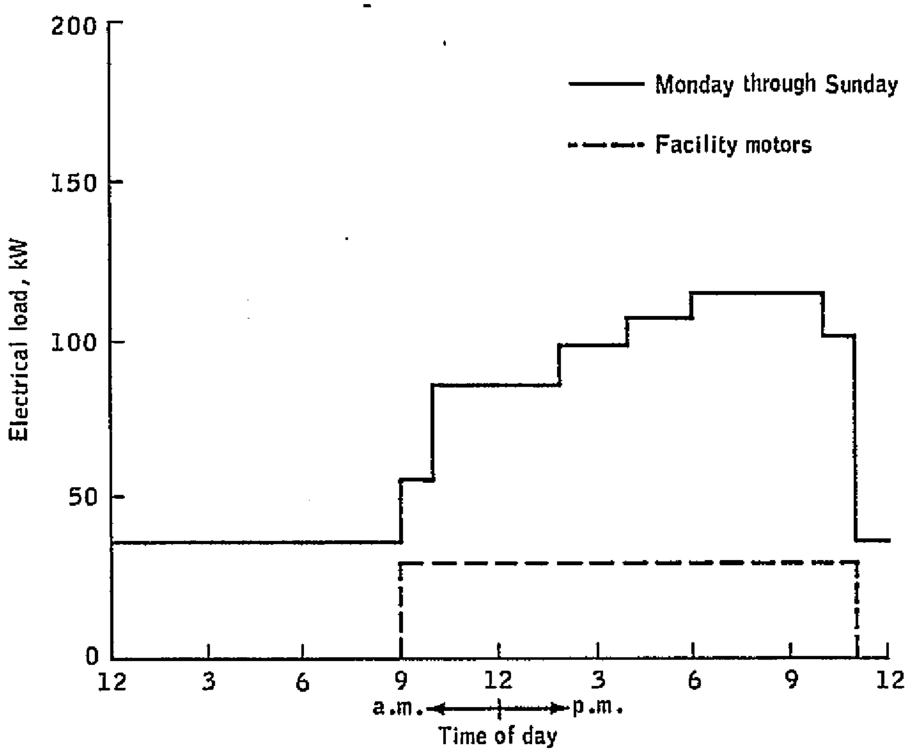


(d) Elementary school.

Figure B-2.- Continued.

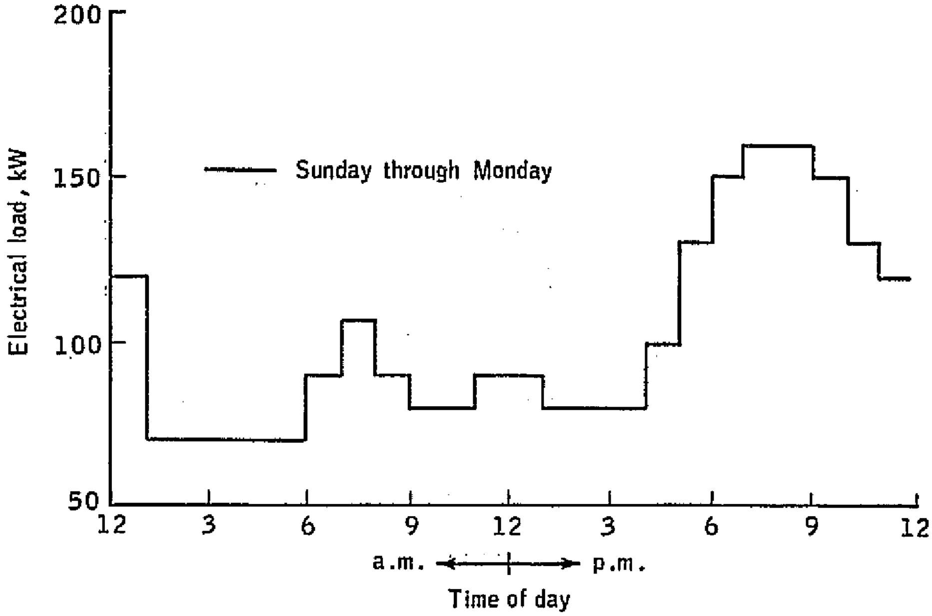


(e) Local shopping center.

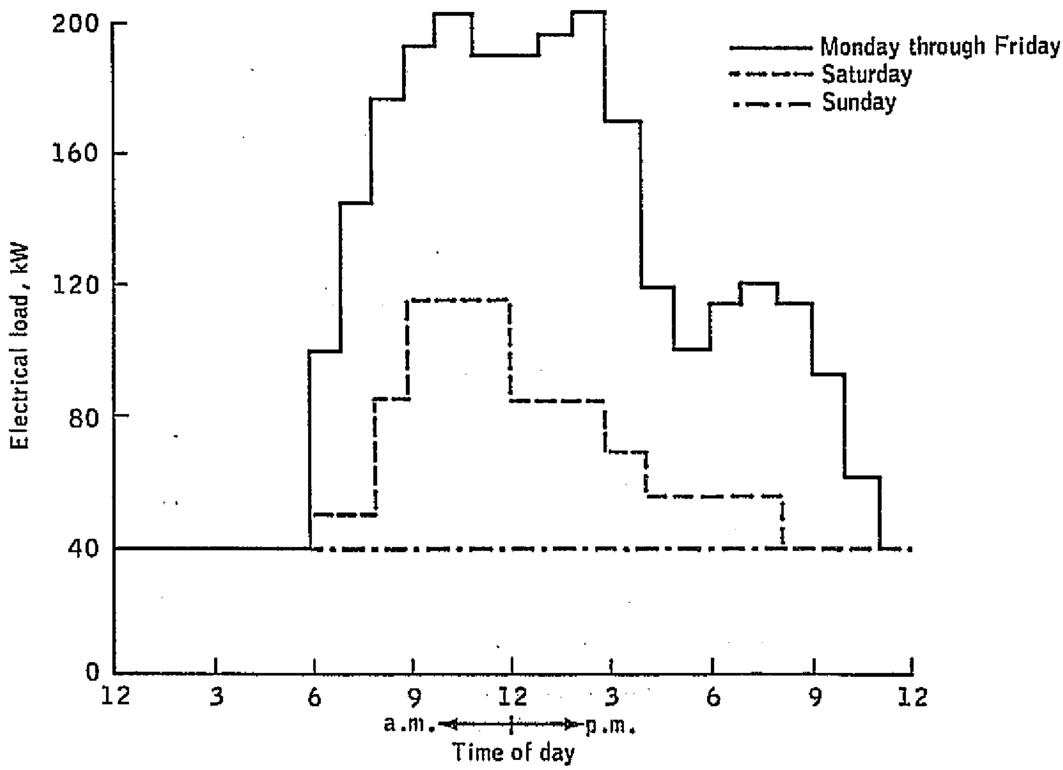


(f) Recreation center.

Figure B-2.- Continued.

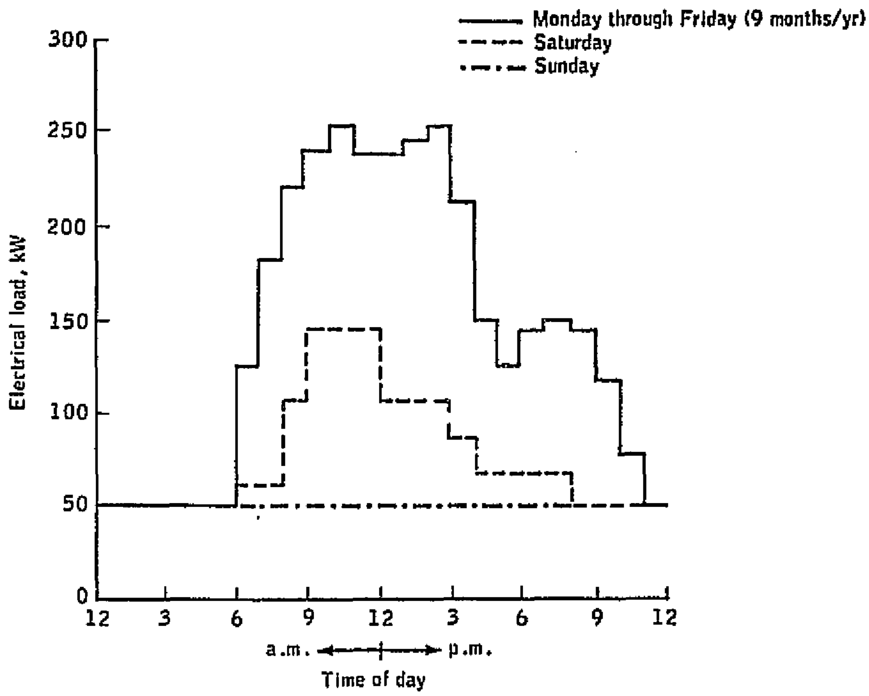


(g) Medium-rise apartments.

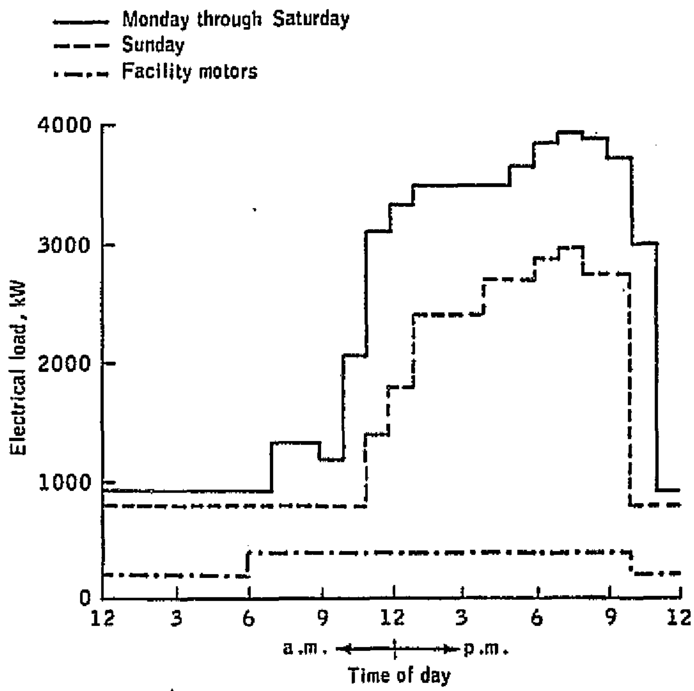


(h) Middle school building.

Figure B-2.- Continued.

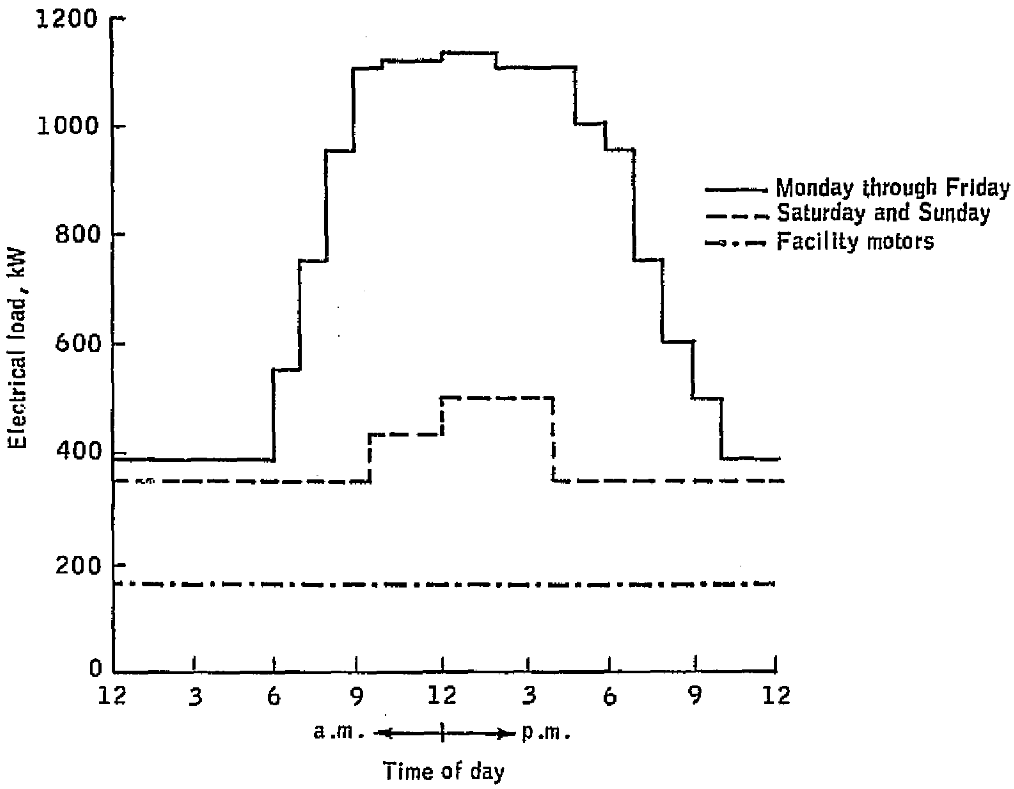


(i) High school.

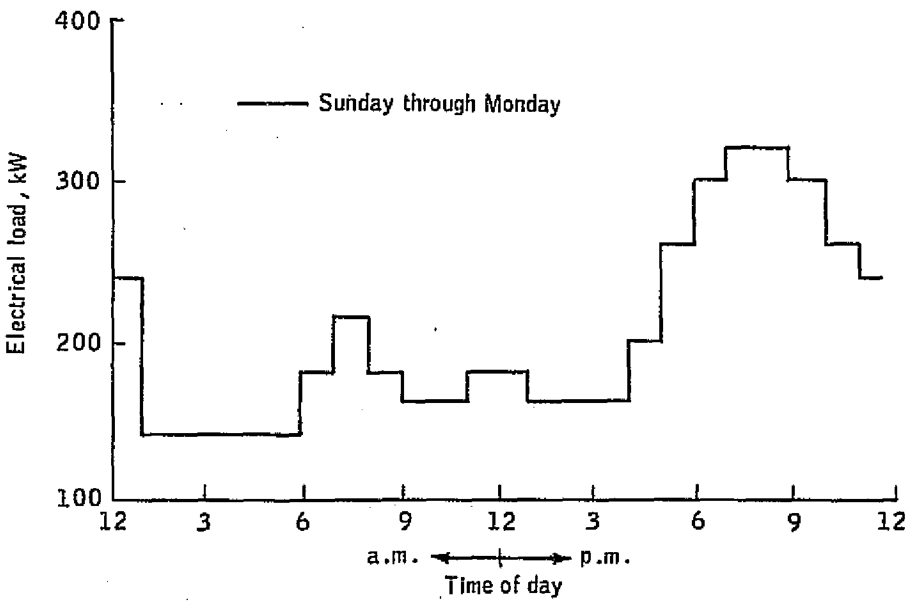


(j) Shopping center. (No environmental conditioning is included except for fan coil units.)

Figure B-2.- Continued.

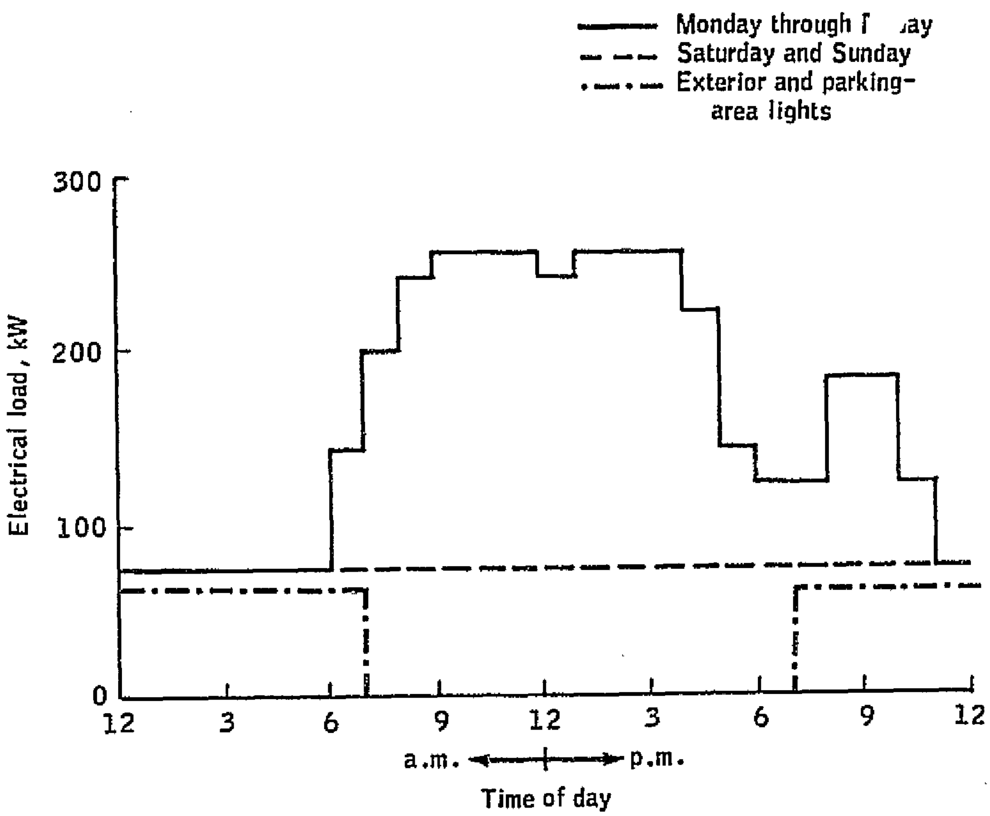


(k) Office building.

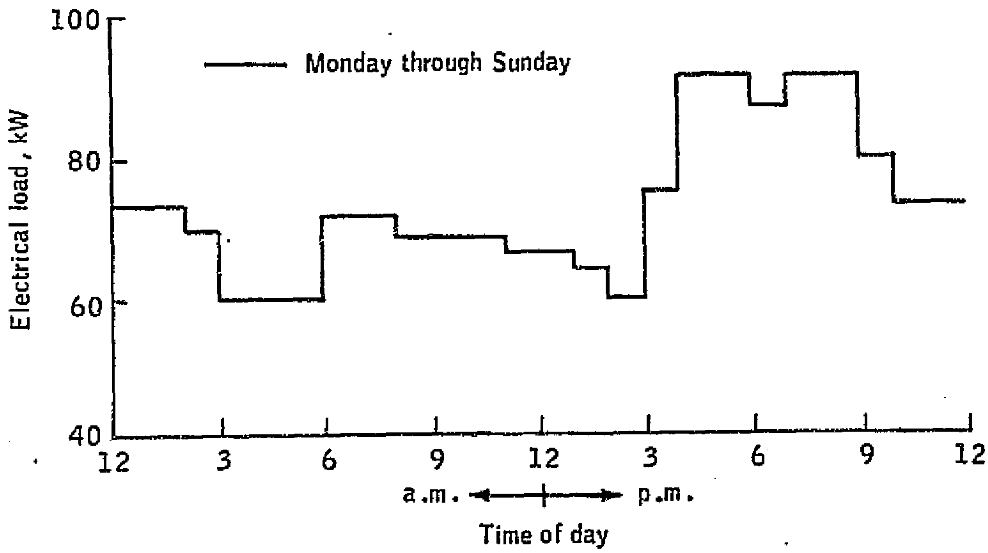


(l) High-rise apartment building.

Figure B-2.- Continued.

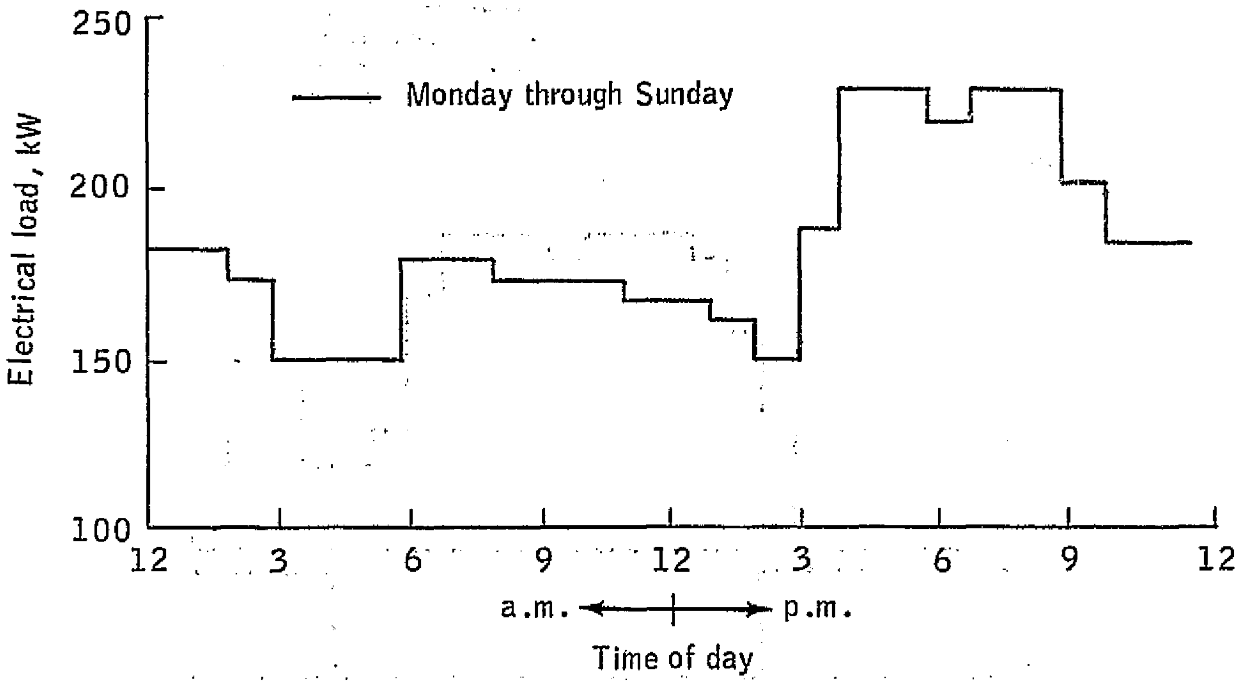


(m) College.

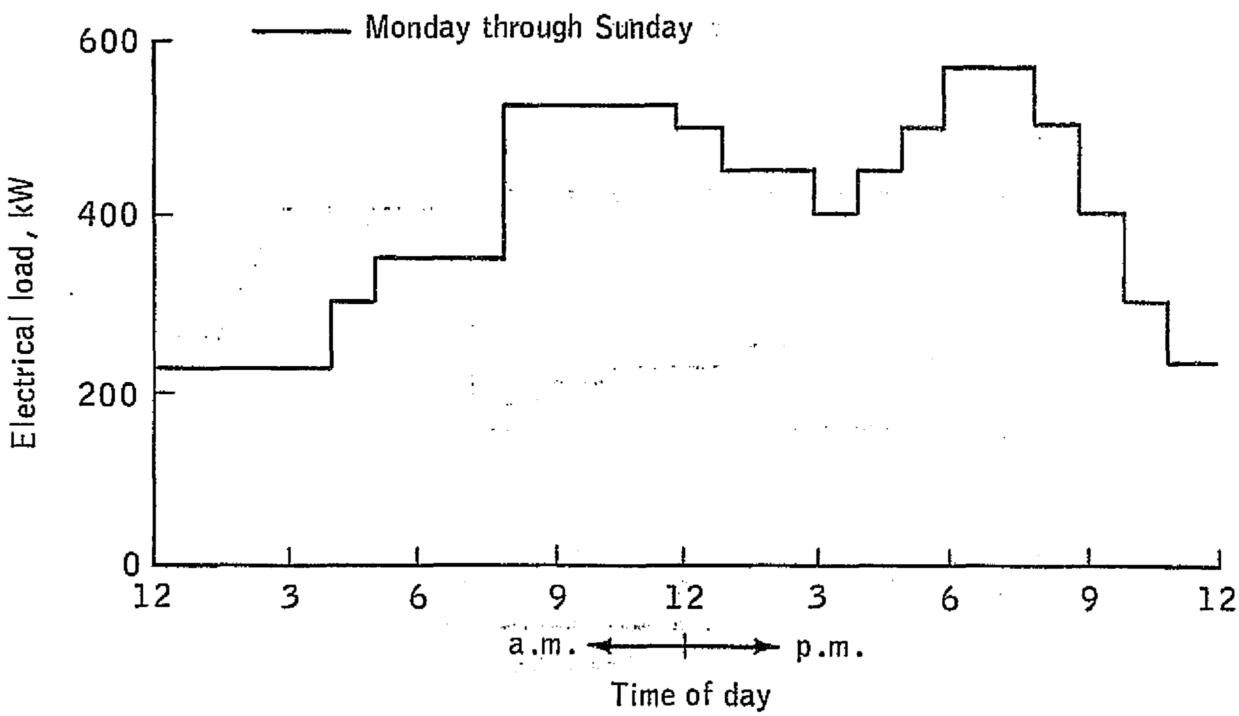


(n) 75-room motel.

Figure B-2.- Continued.



(o) 200-room high-rise hotel.



(p) 384-bed hospital.

Figure B-2.- Concluded.

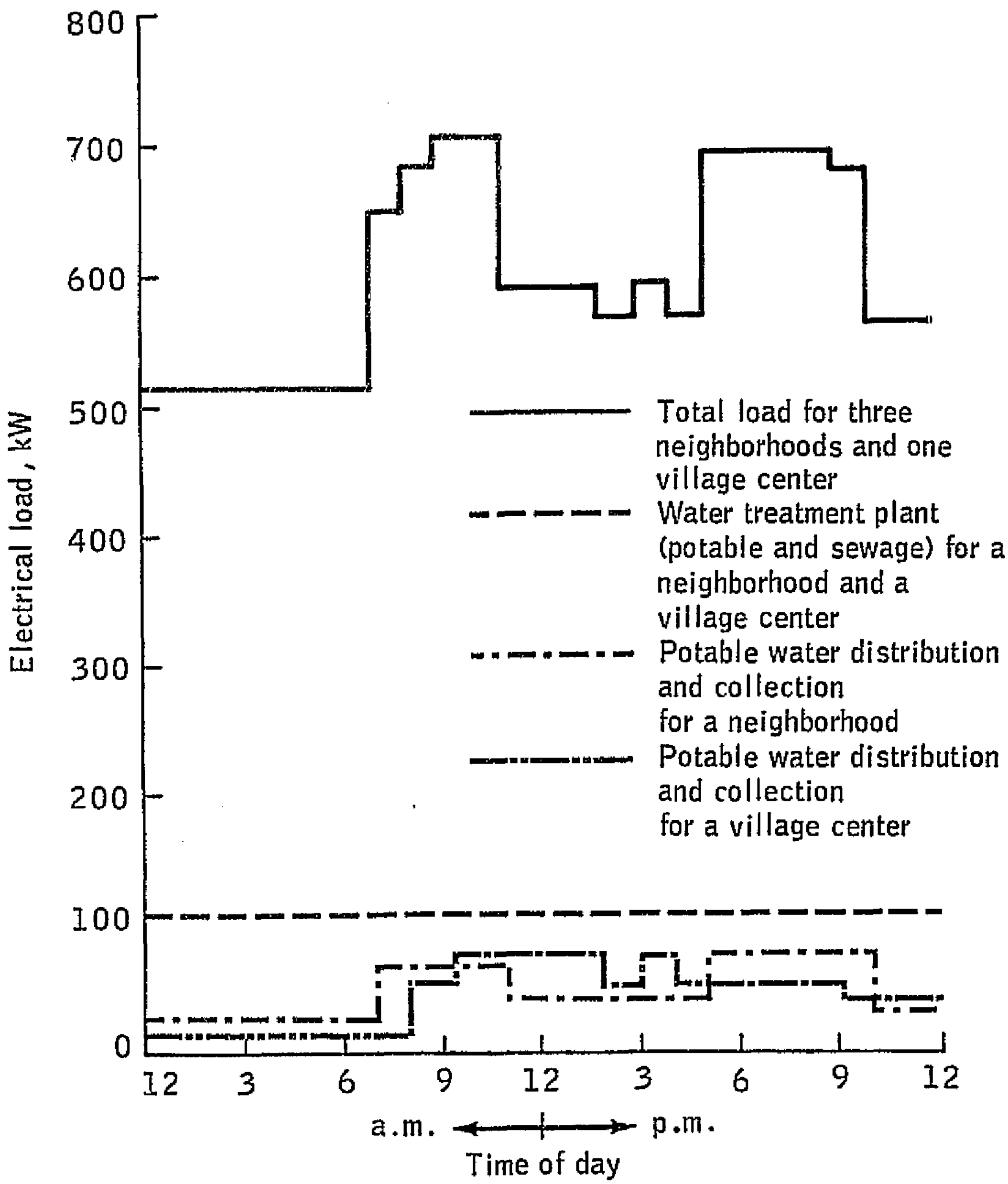
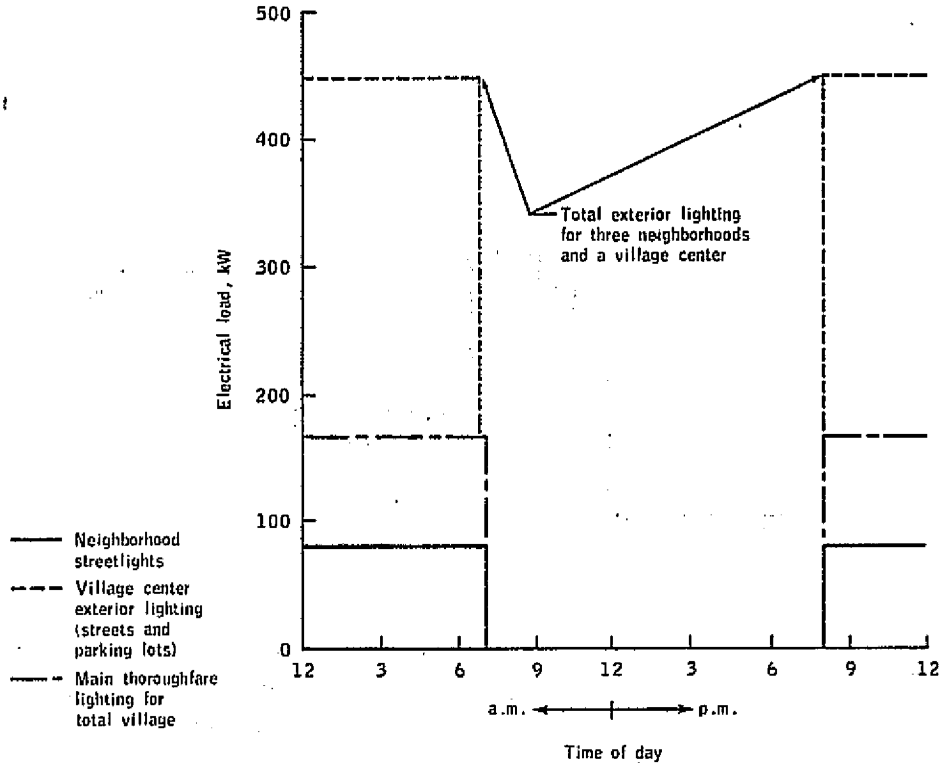
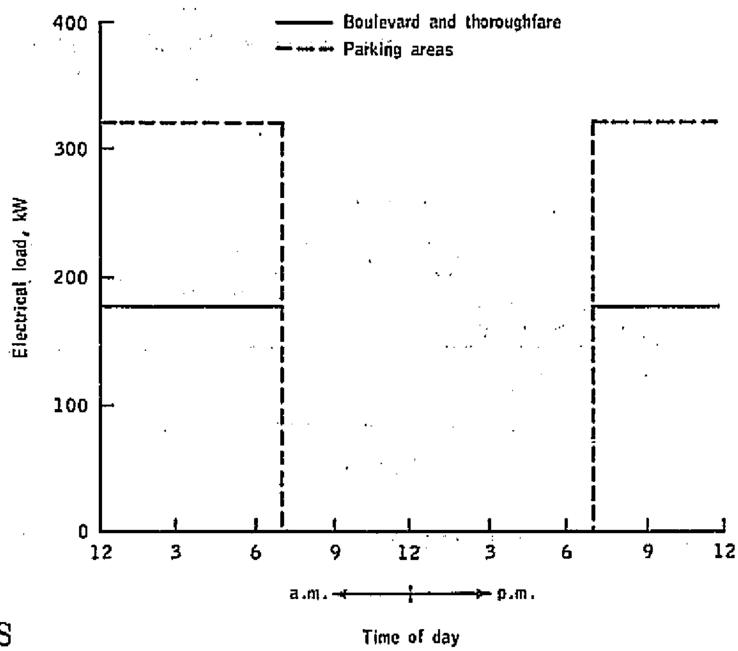


Figure B-3.- Water treatment plant and distribution motor loads.



(a) Neighborhood.



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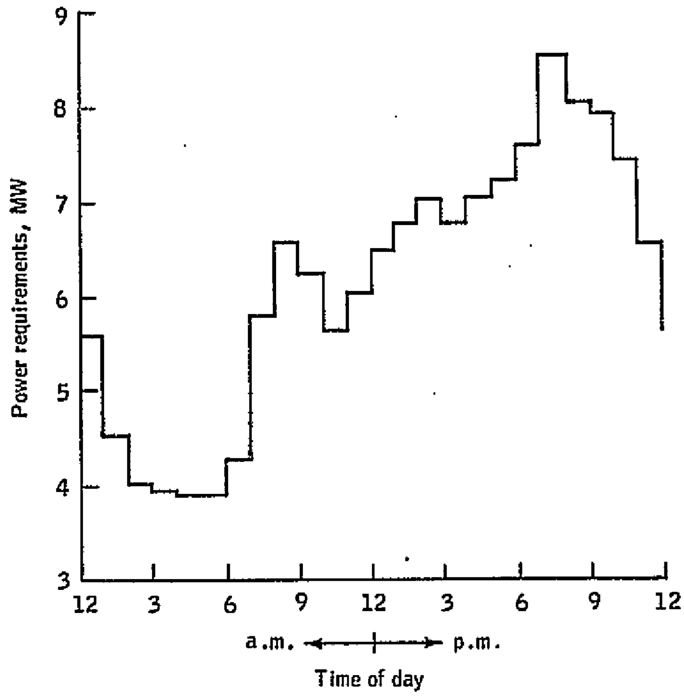
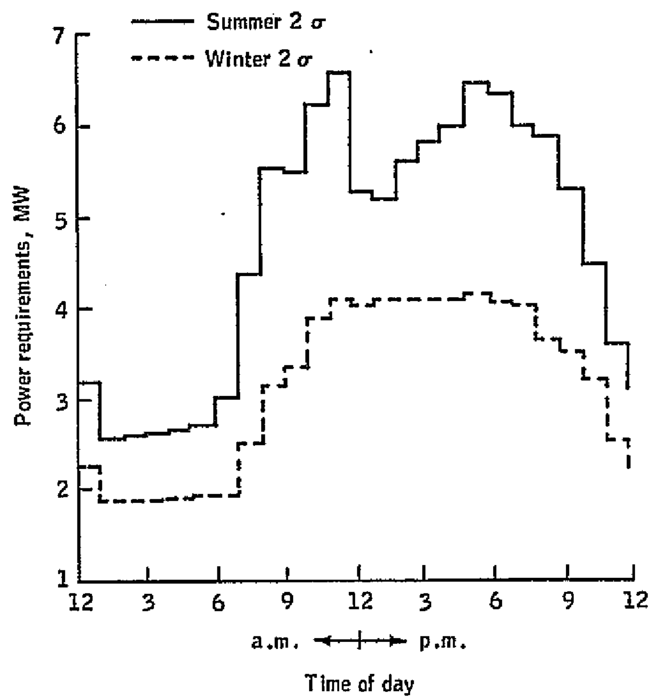
(b) Town center.

Figure B-4.- Electrical load profiles for street lighting.

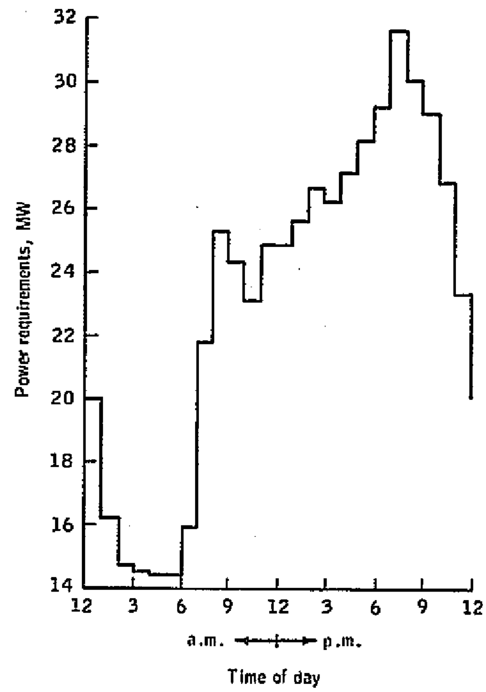


(a) Neighborhood MIUS.

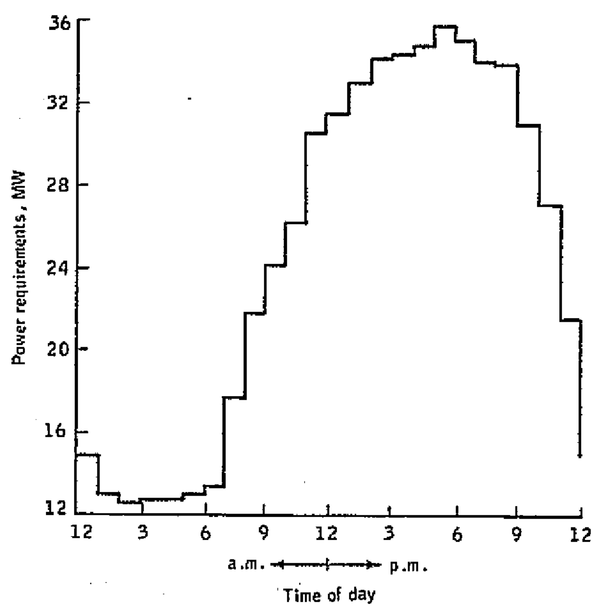


(b) Village center MIUS.

Figure B-5.- Power profiles (2-sigma summer, floating air-conditioning).

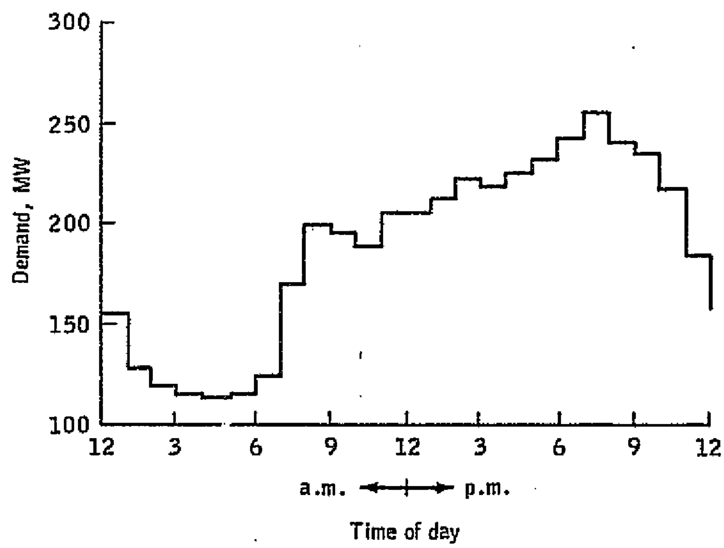


(c) Village complex MIUS.



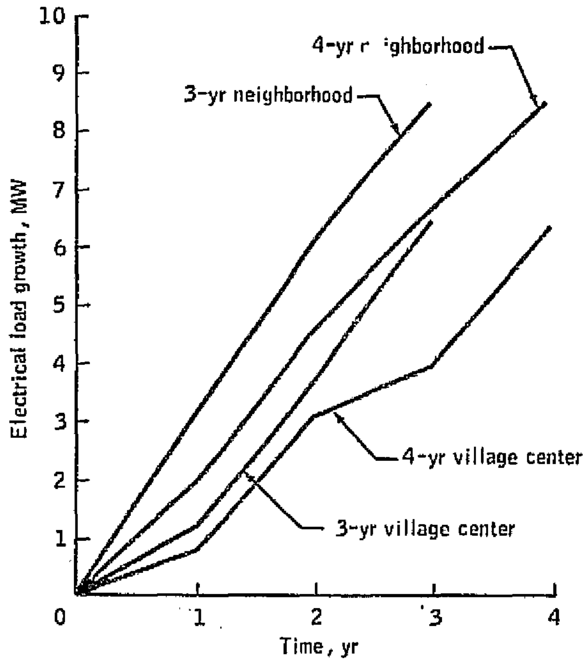
(d) CBD MIUS.

Figure B-5.- Continued.

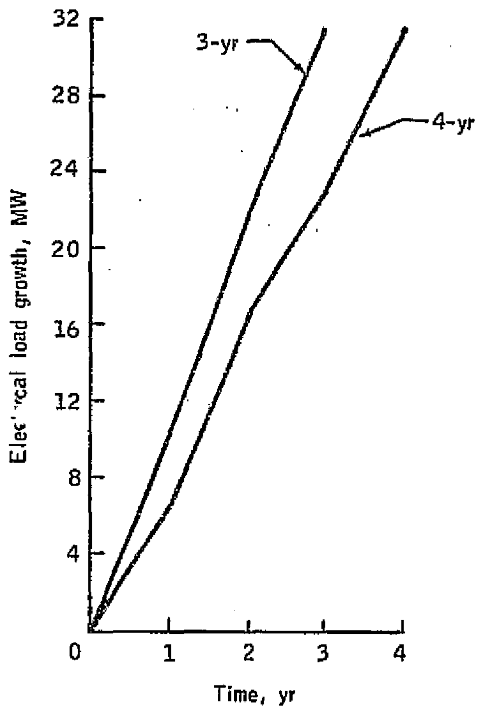


(e) Total community.

Figure B-5.- Concluded.

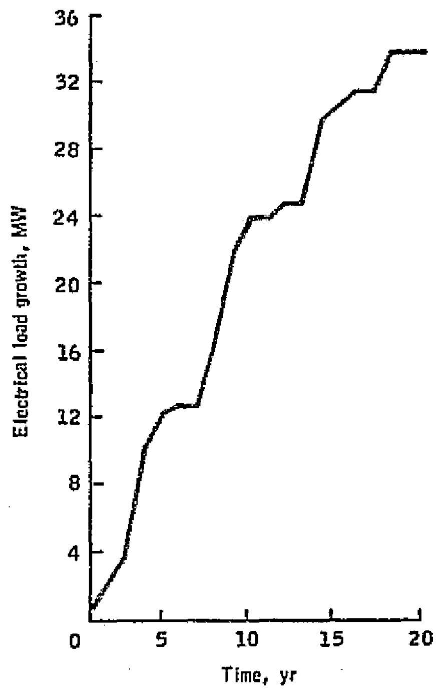


(a) Neighborhood and village center (option I).

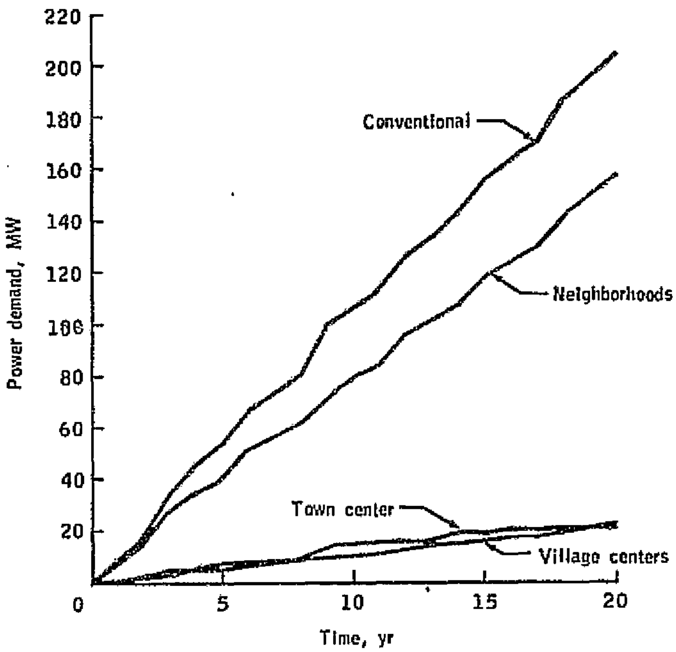


(b) Village complex (option II).

Figure B-6.- Electrical load growth.

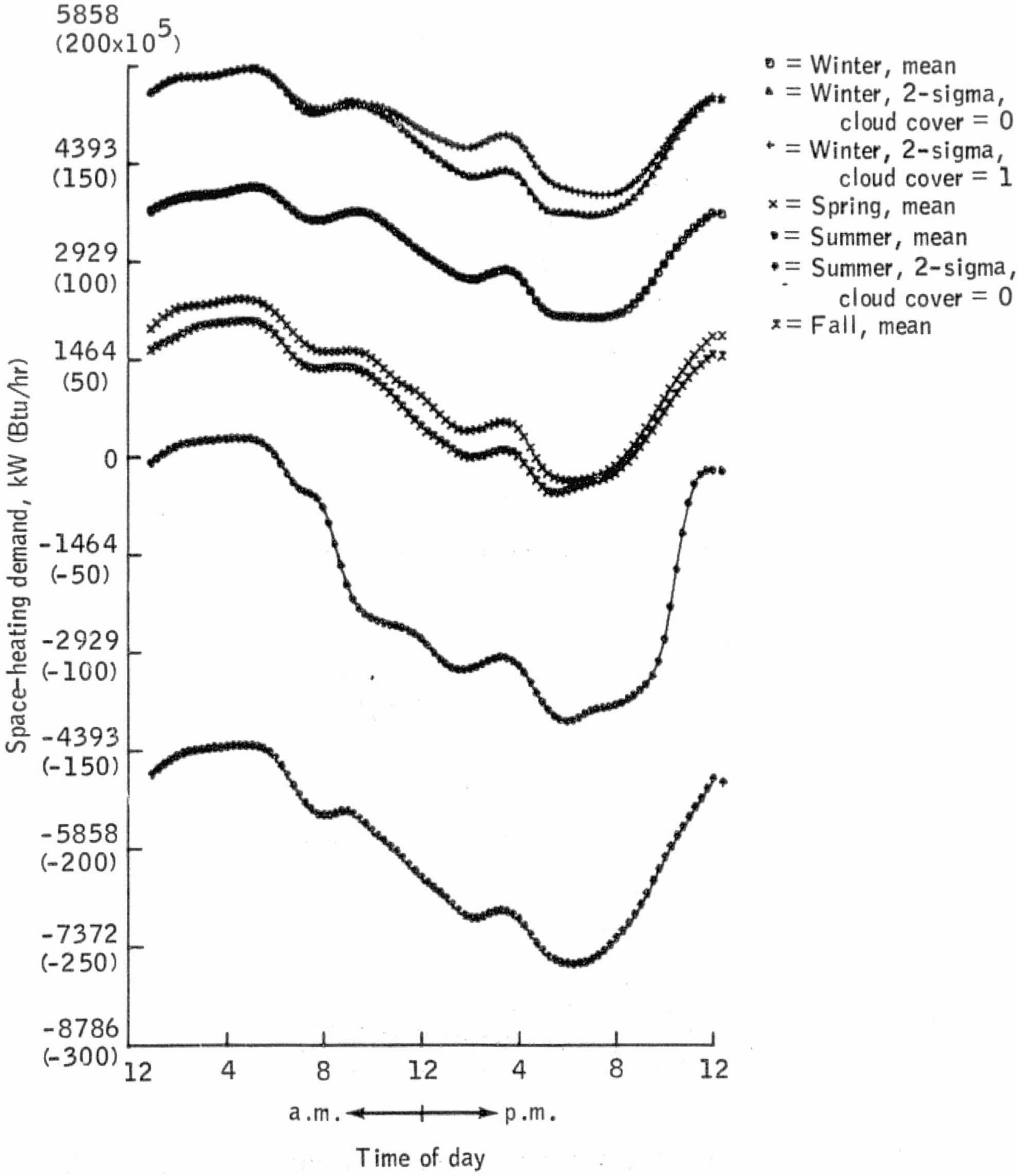


(c) CBD (options I and II).



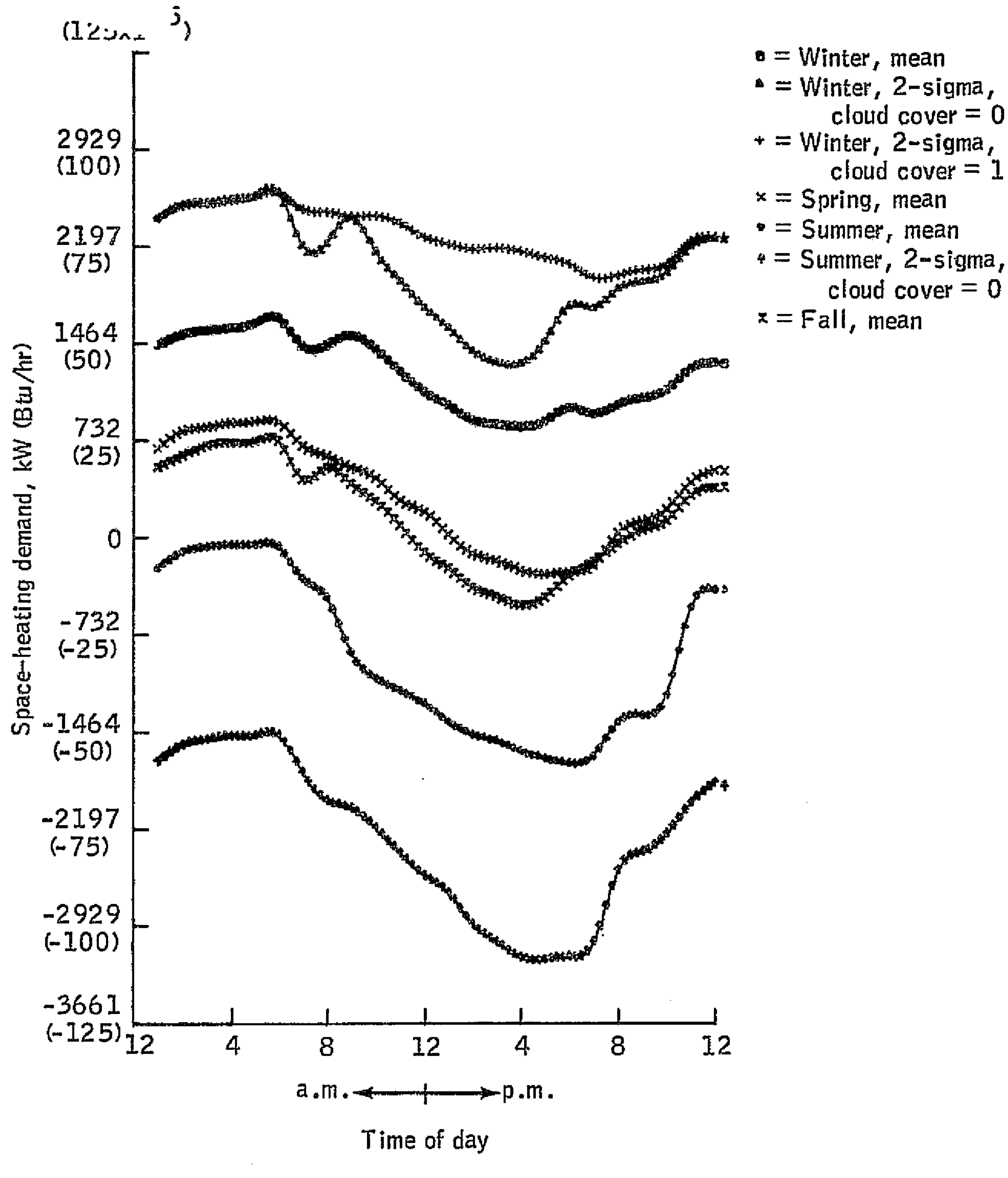
(d) Comparison of MIUS and conventional systems total project domestic electrical growth (includes air-conditioning for single-family dwellings); design case, 7 p.m.

Figure B-6.- Concluded.



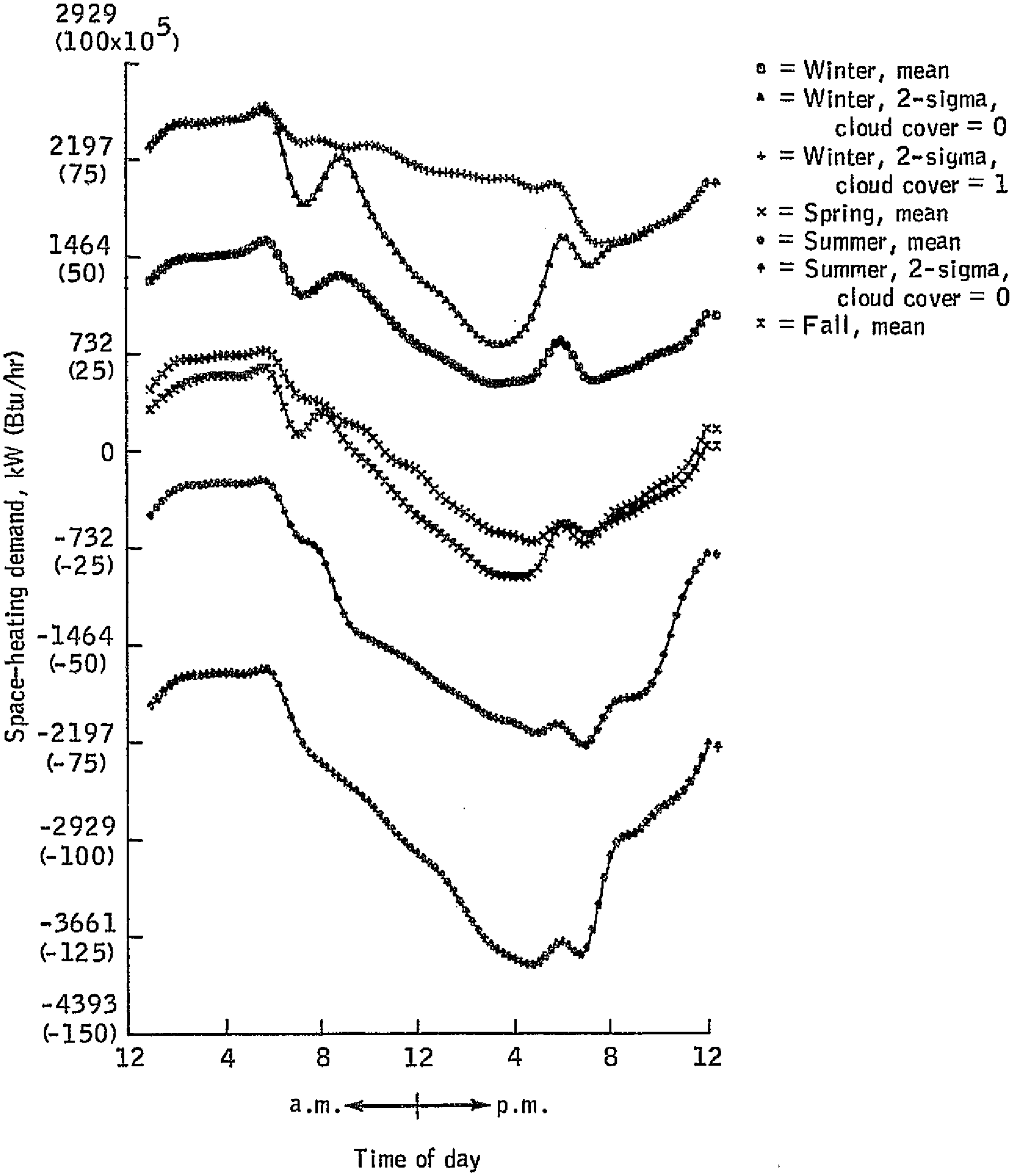
(a) Single-family dwelling.

Figure B-7.- Daily profiles for heating/cooling loads for each season.



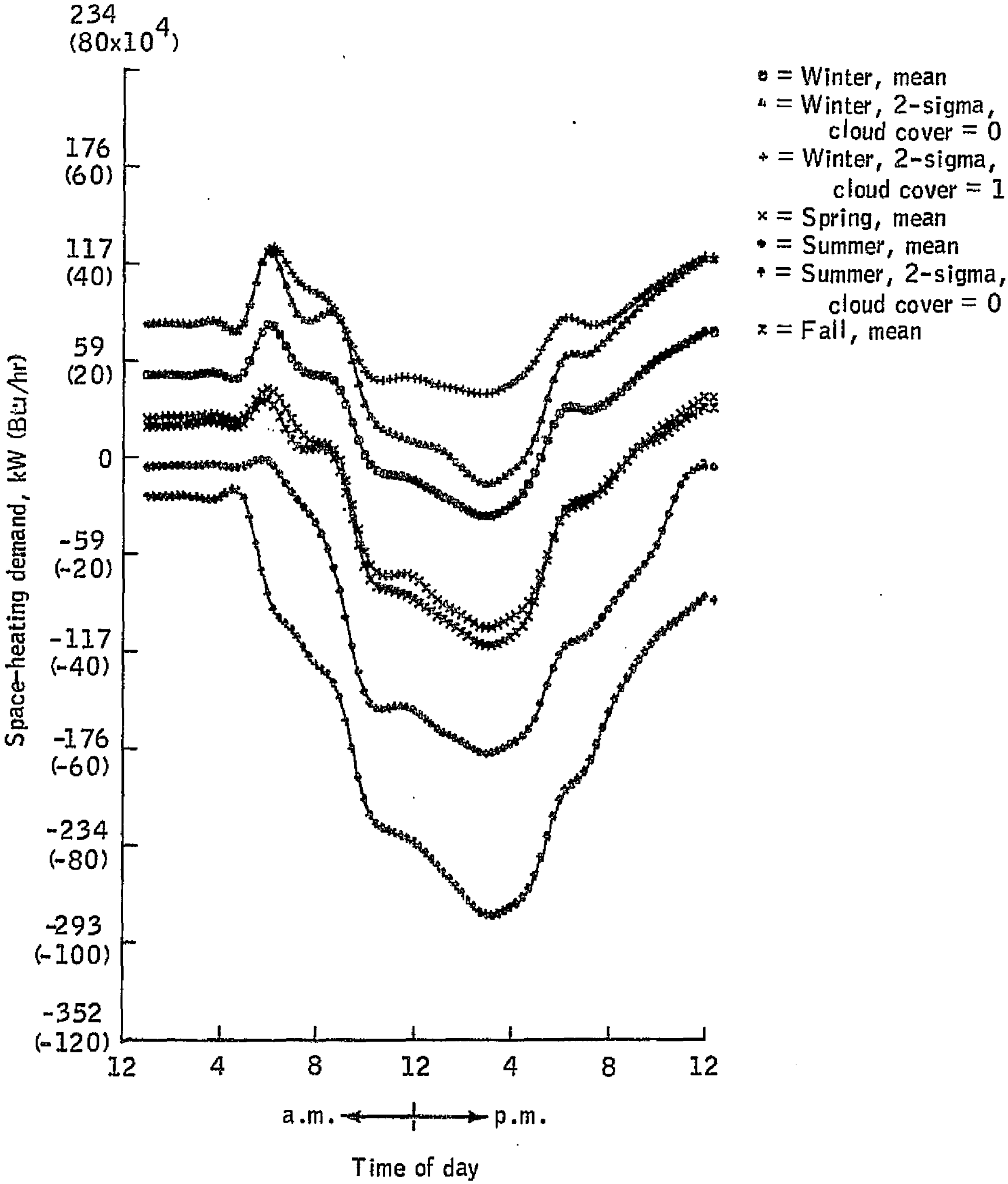
(b) Townhouse.

Figure B-7.- Continued.



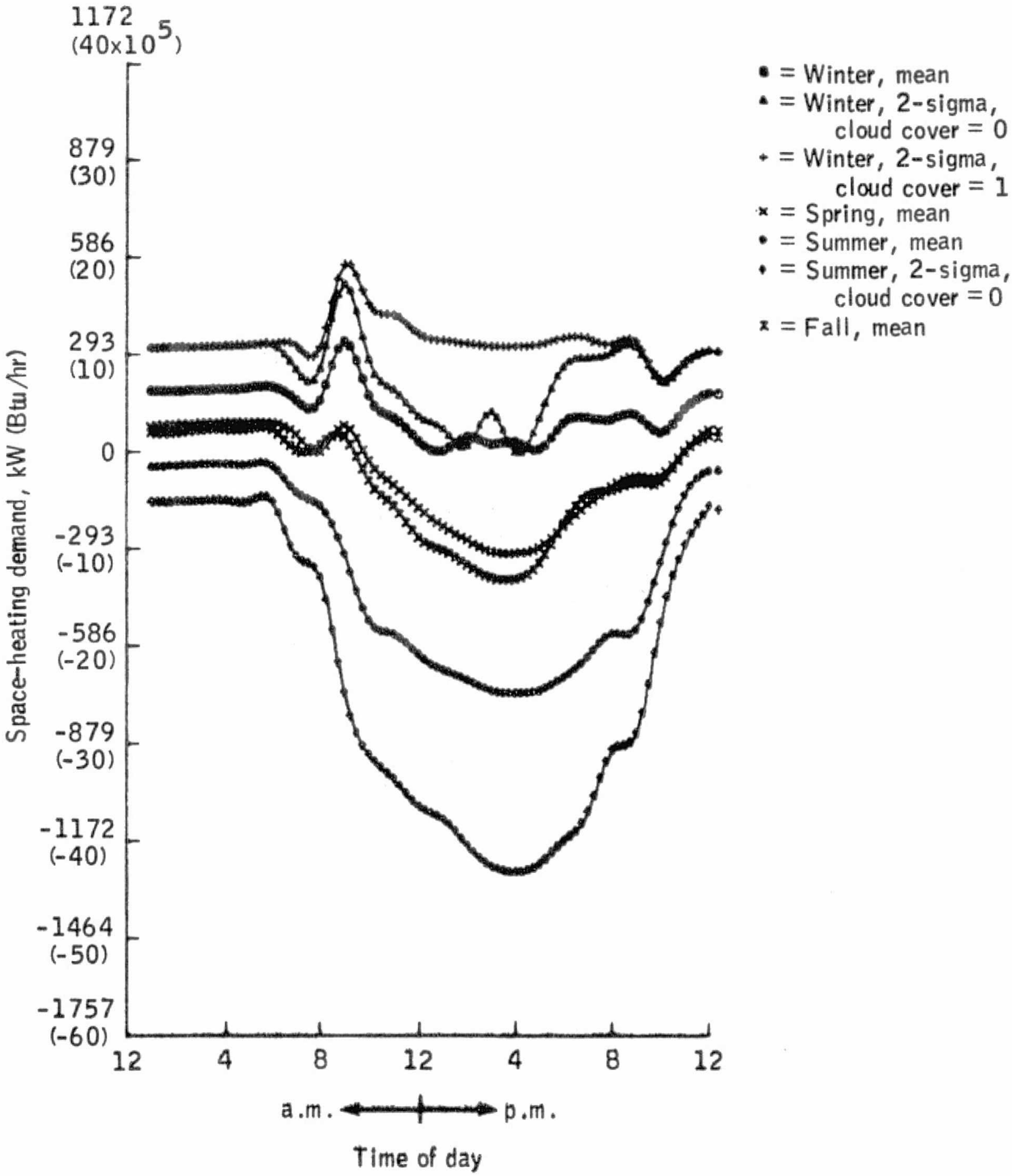
(c) Garden apartment.

Figure B-7.- Continued.



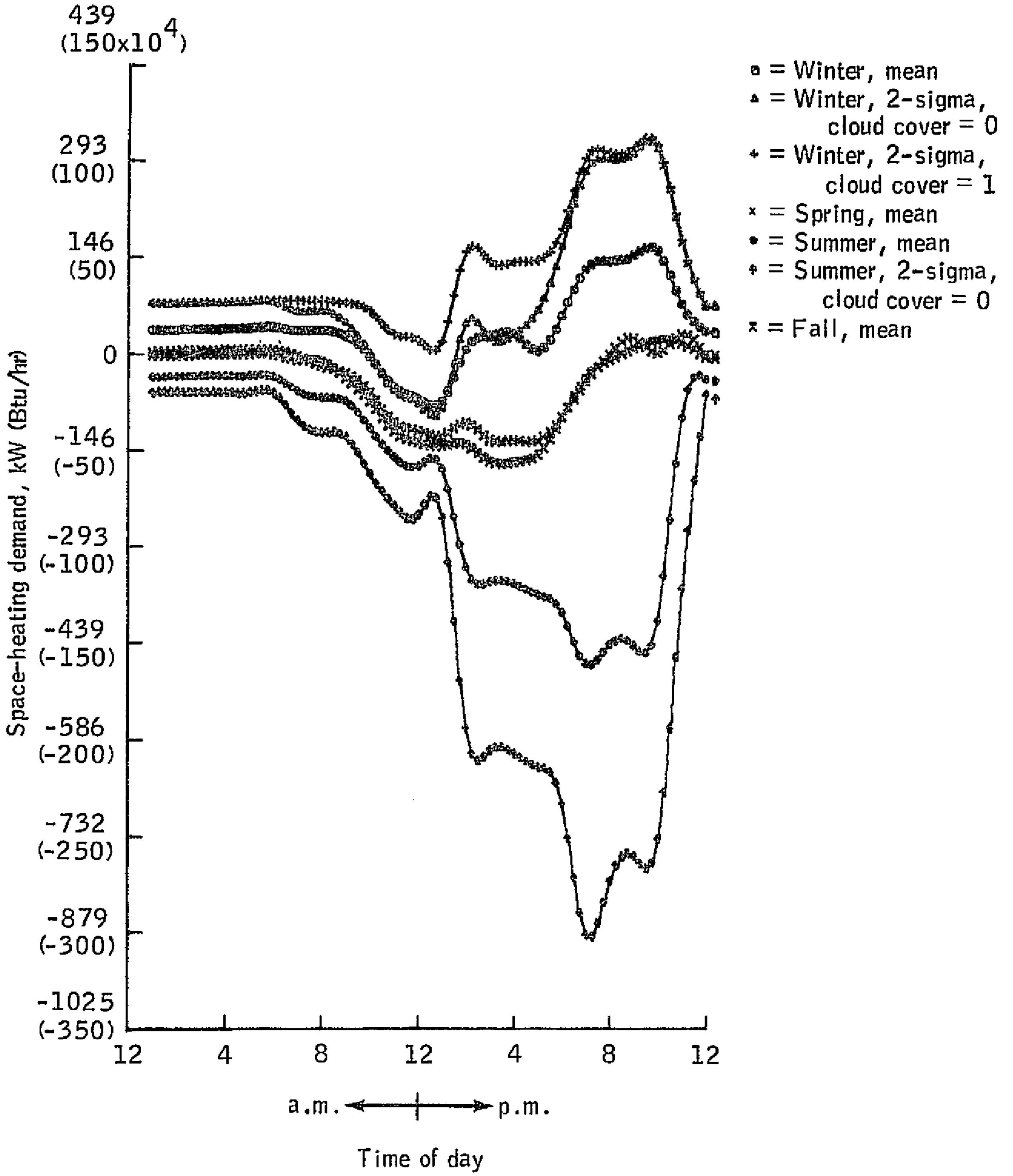
(d) Elementary school.

Figure B-7.- Continued.



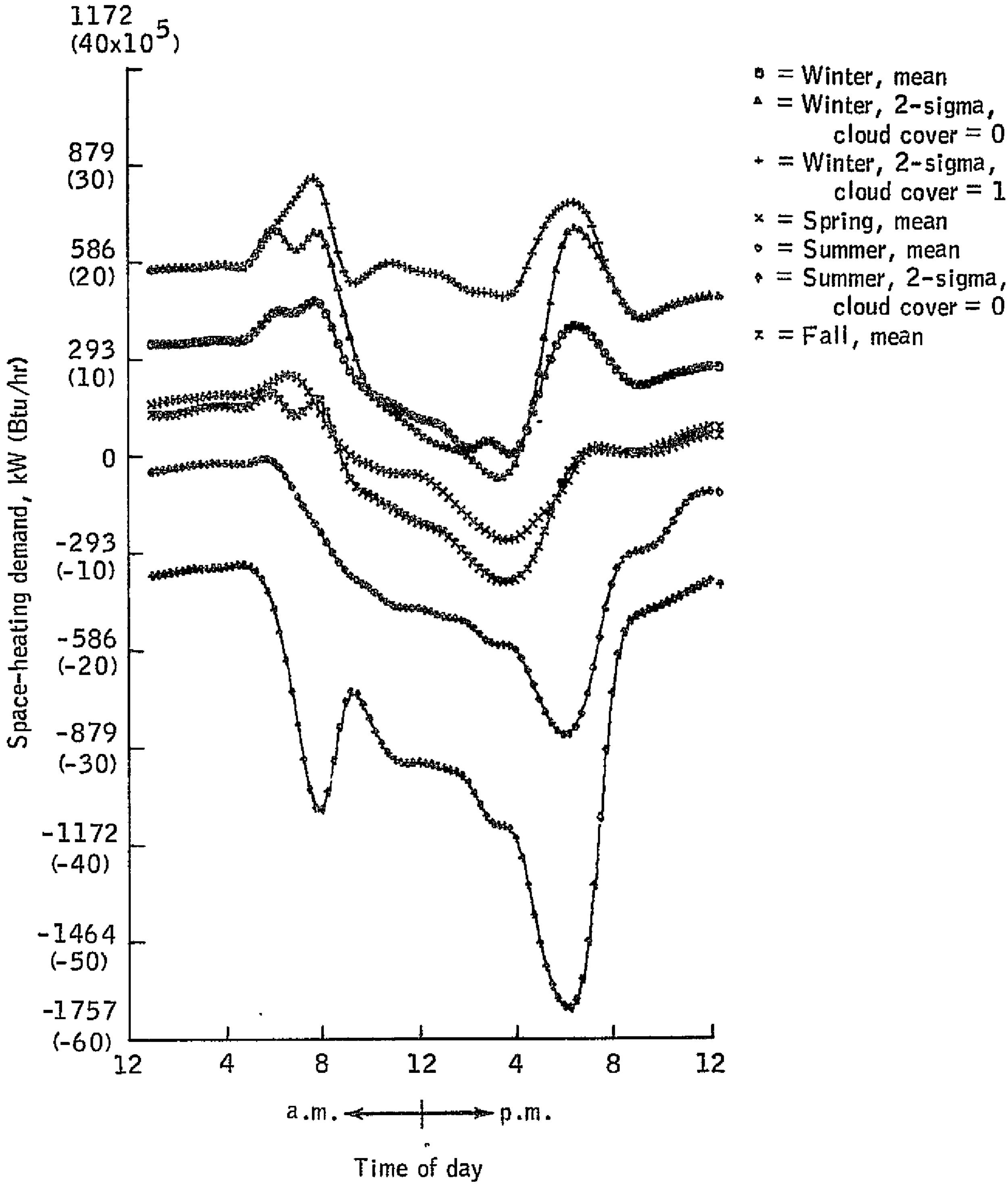
(e) Local shopping center.

Figure B-7.- Continued.



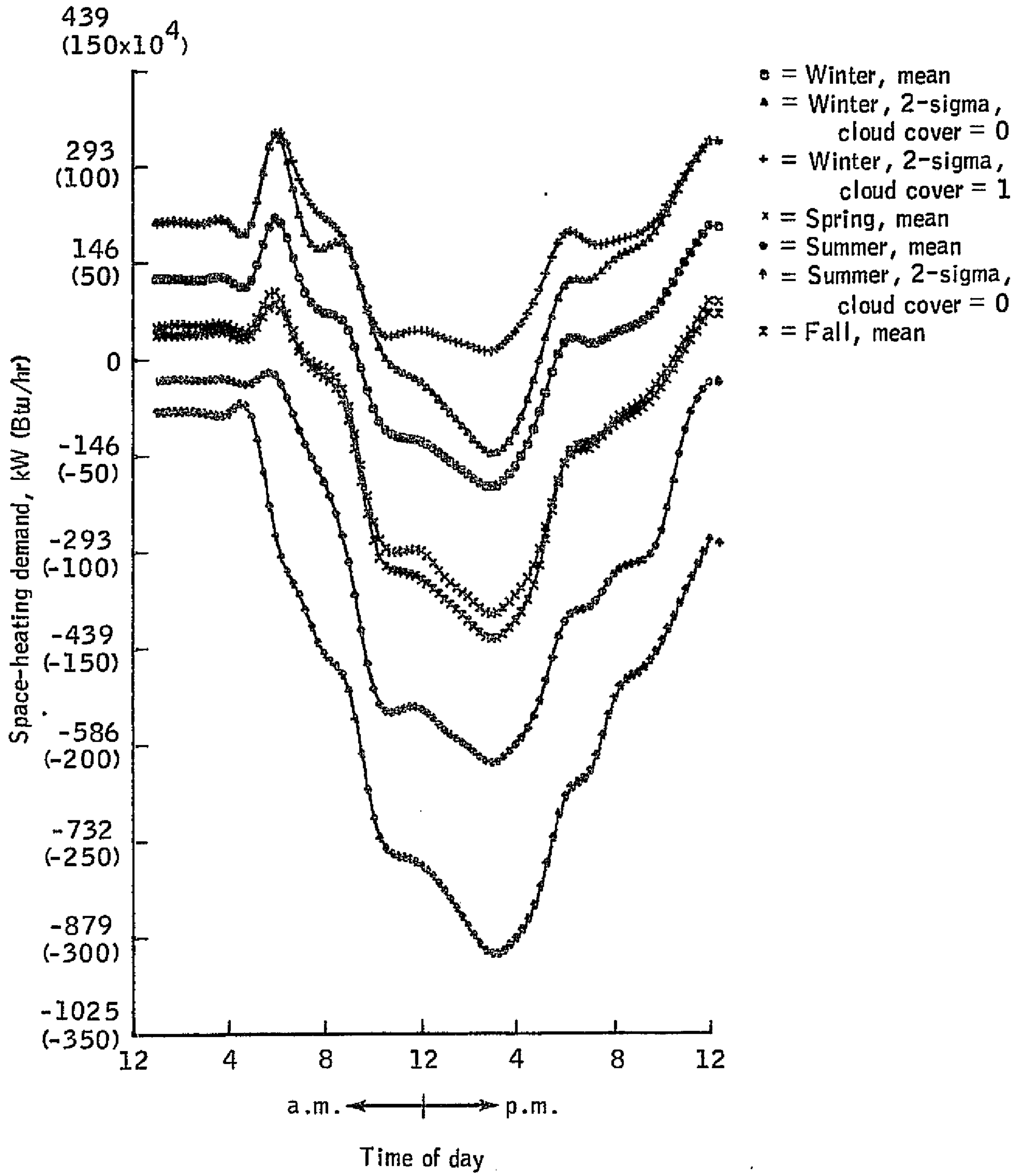
(f) Recreation area.

Figure B-7.- Continued.



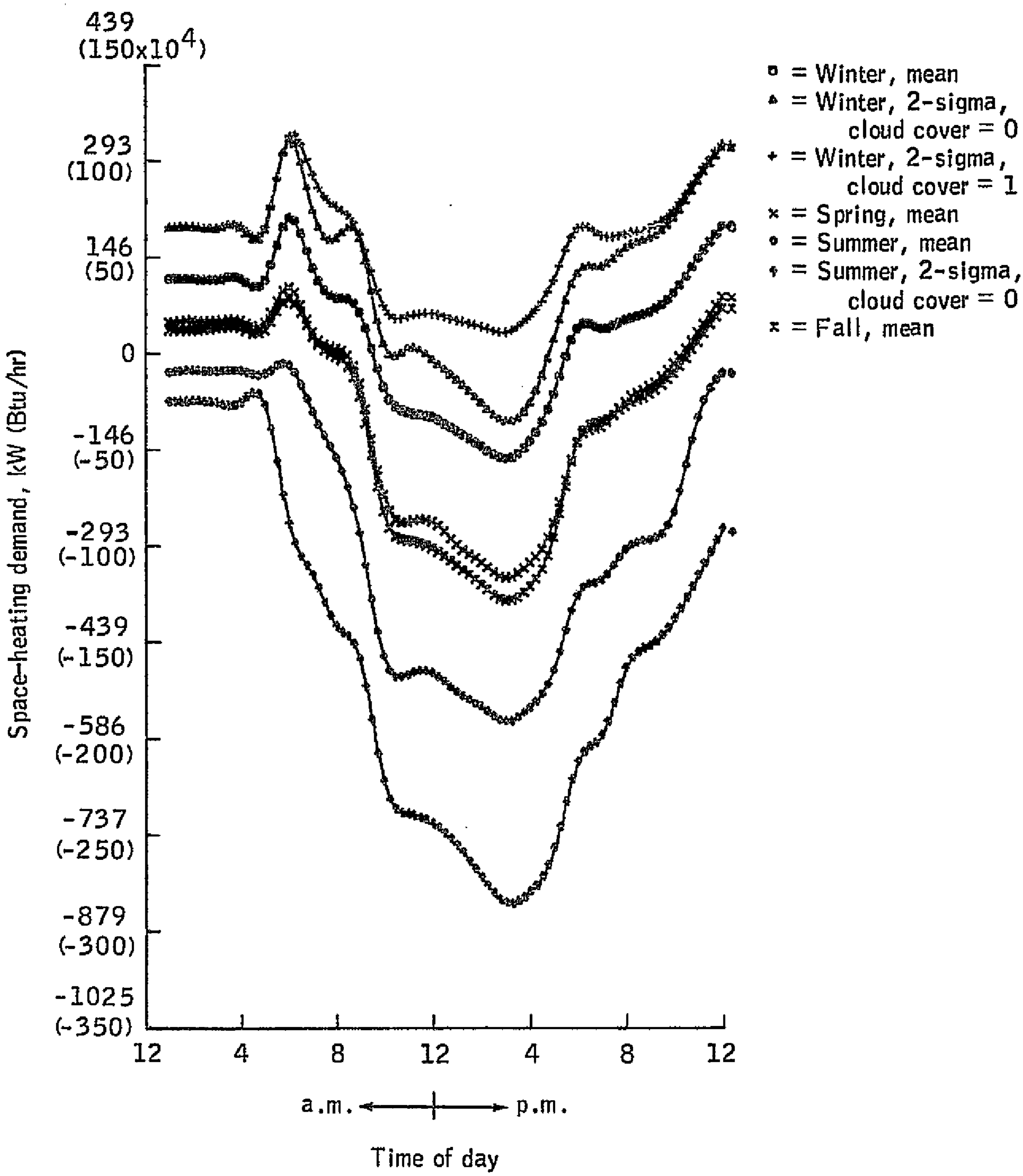
(g) Medium-rise apartment.

Figure B-7.- Continued.



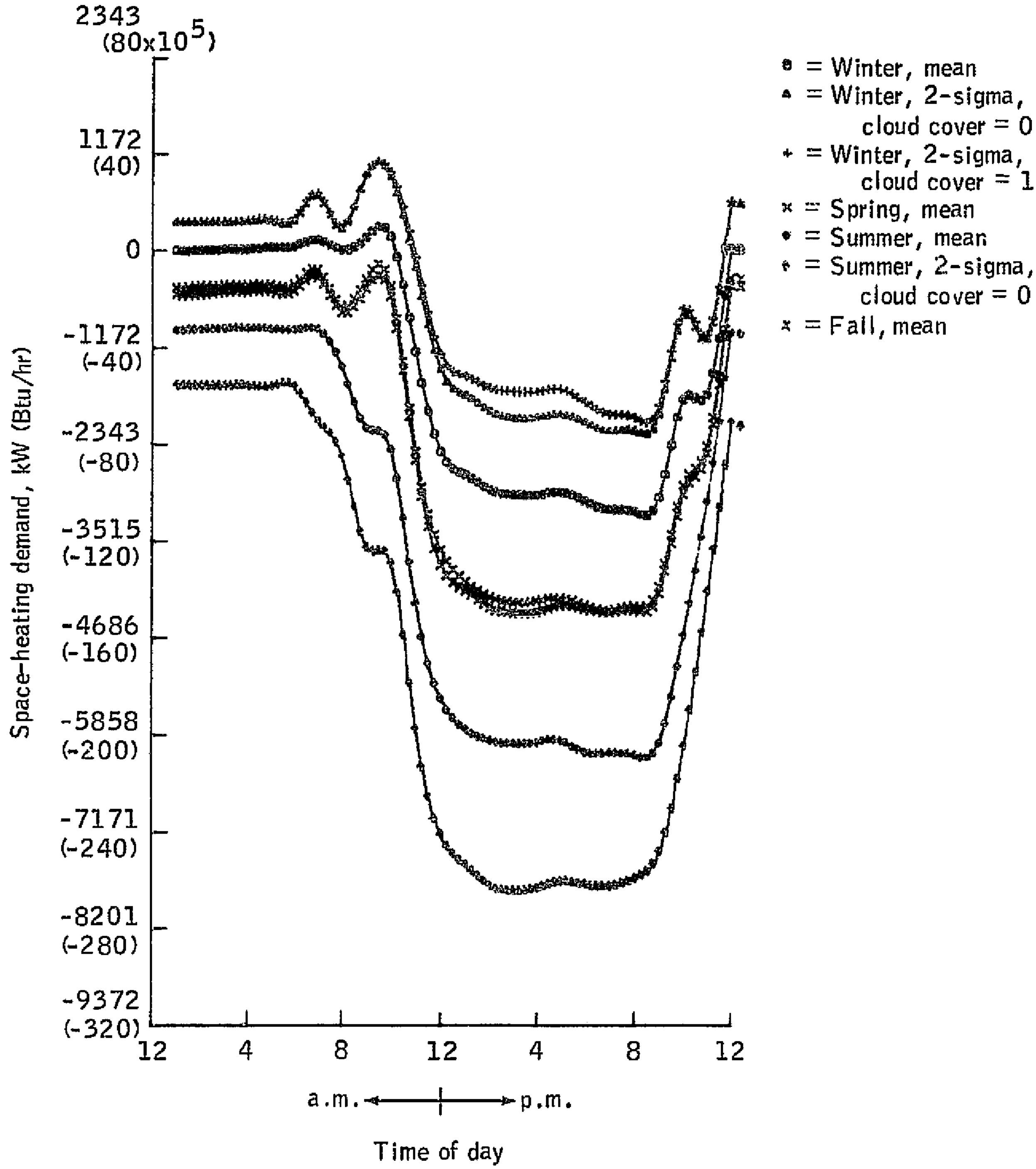
(h) Middle school.

Figure B-7.- Continued.



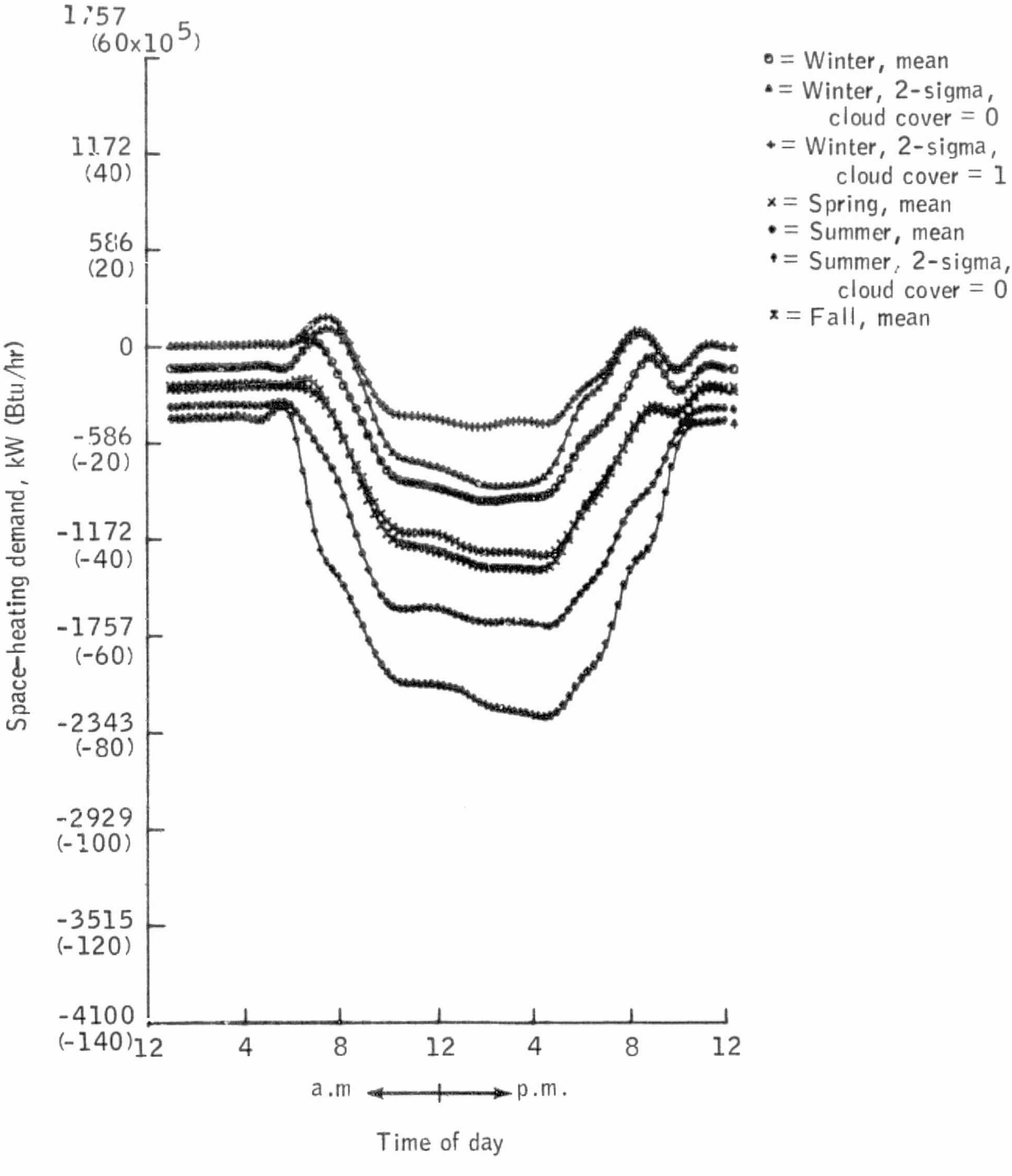
(i) High school.

Figure B-7.- Continued.



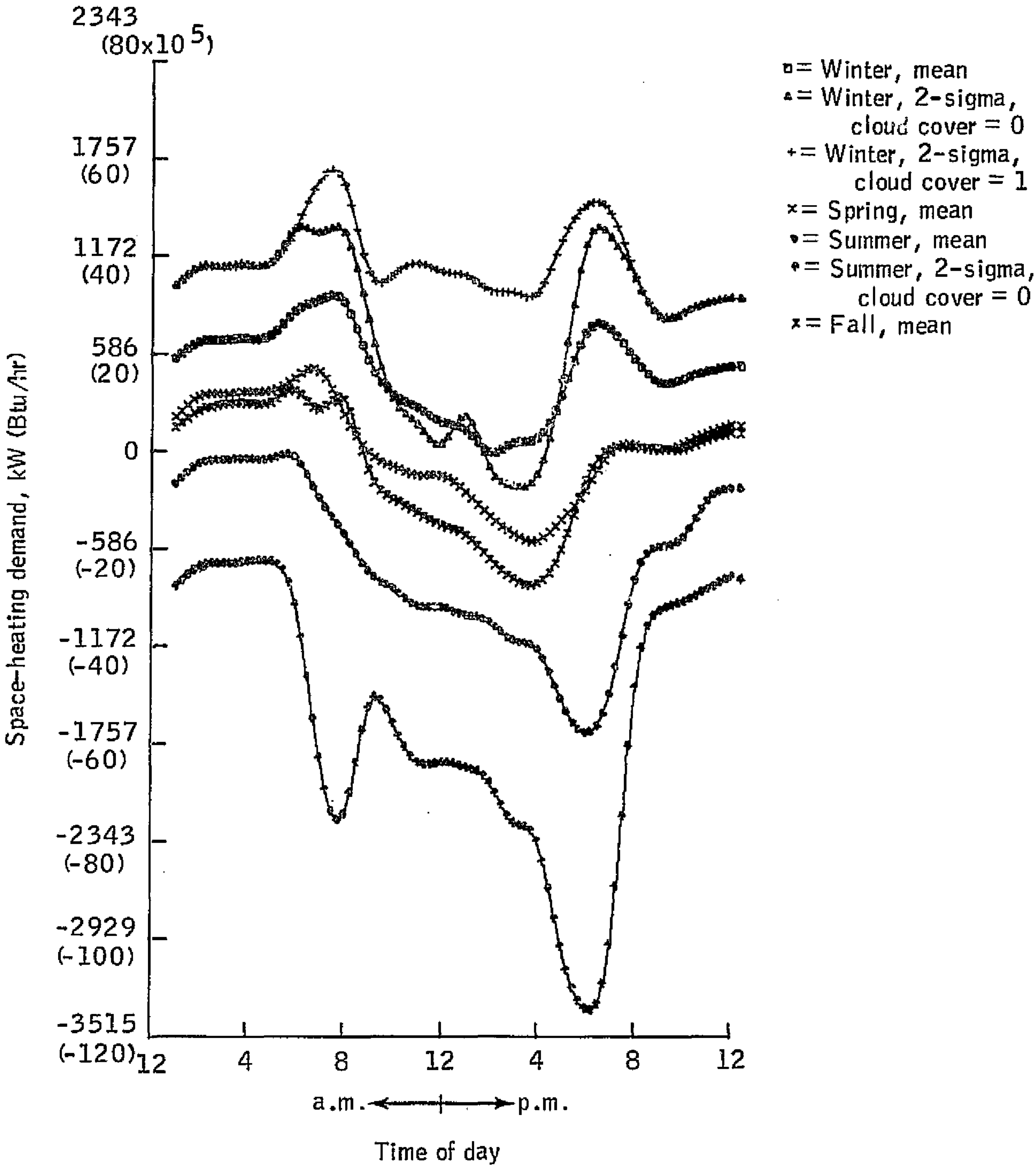
(j) Regional shopping center.

Figure B-7.- Continued.



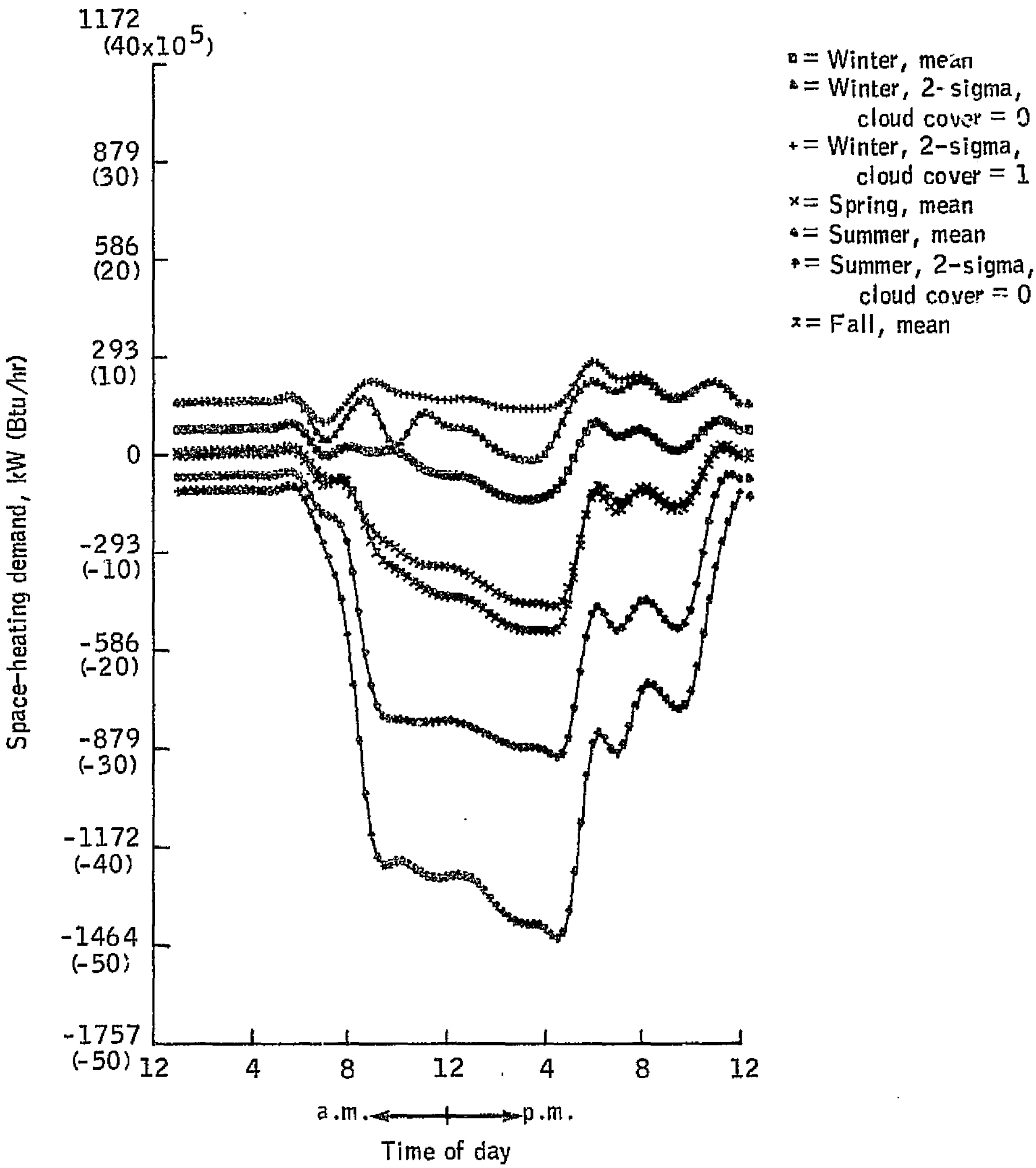
(k) Office building.

Figure B-7.- Continued.



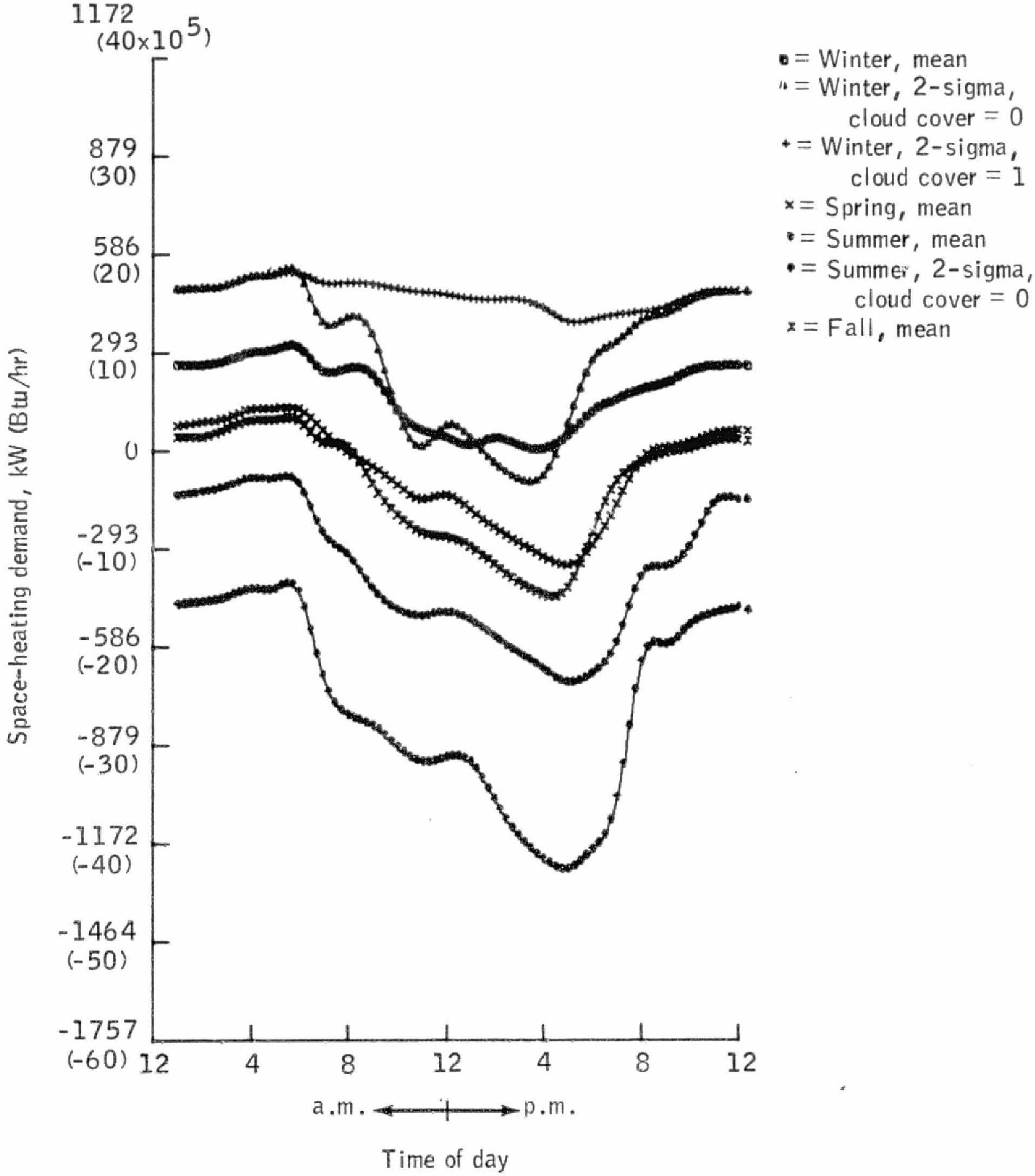
(1) High-rise apartment.

Figure B-7.- Continued.



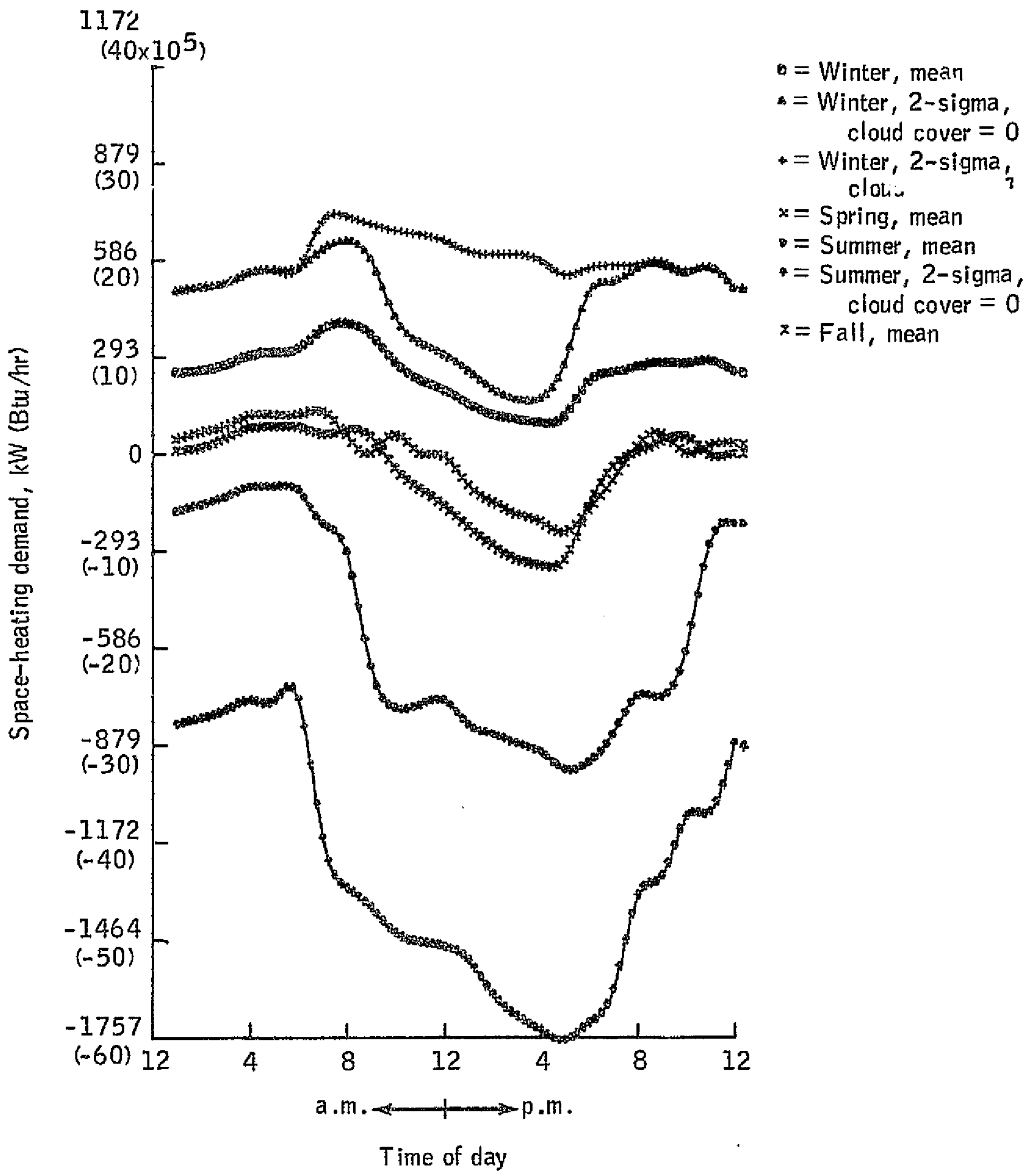
(m) College.

Figure B-7.- Continued.



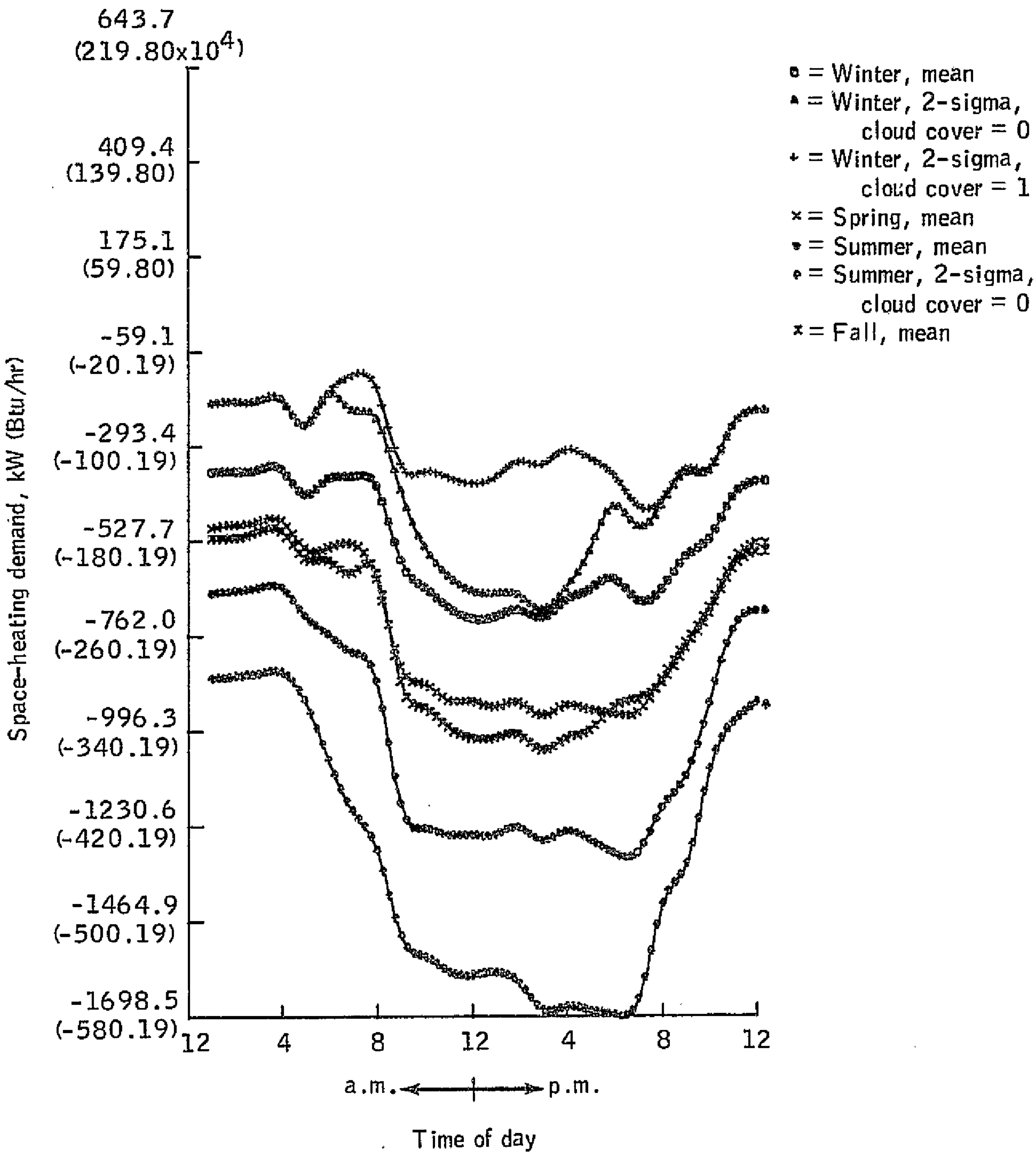
(n) Motel.

Figure B-7.- Continued.



(o) Hotel.

Figure B-7.- Continued.



(p) Hospital.

Figure B-7.- Concluded.

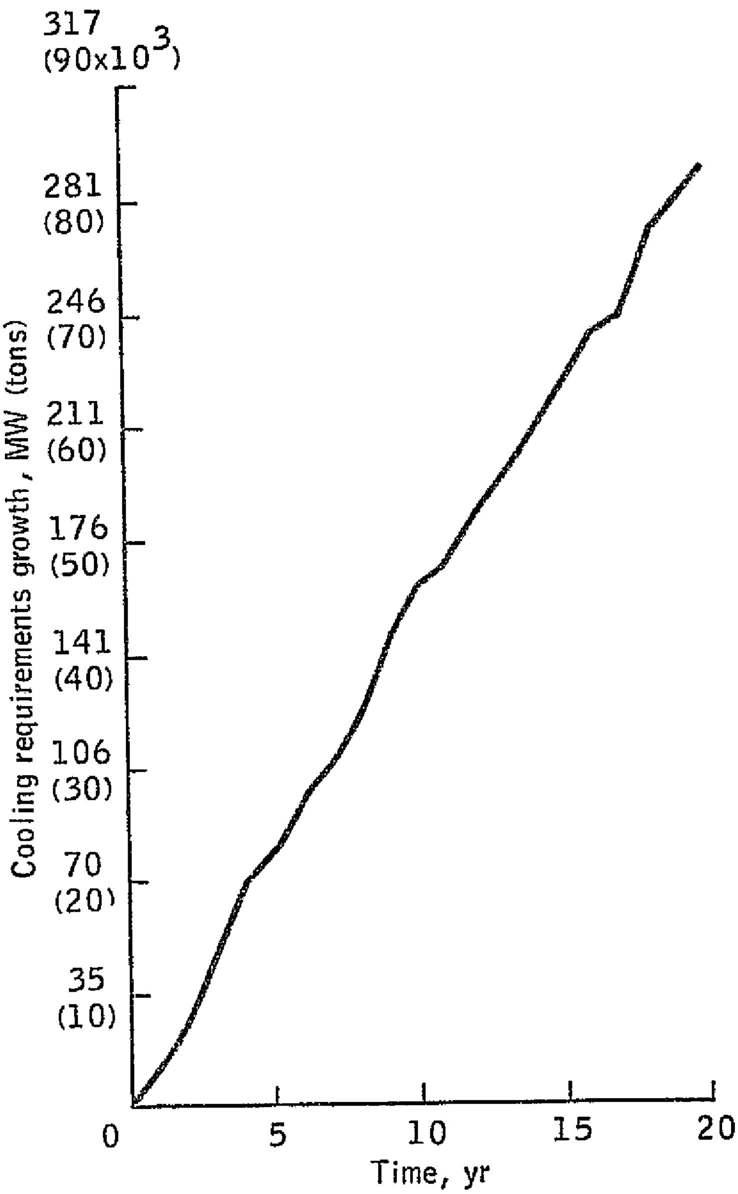


Figure B-8.- Total project cooling load growth; design case.

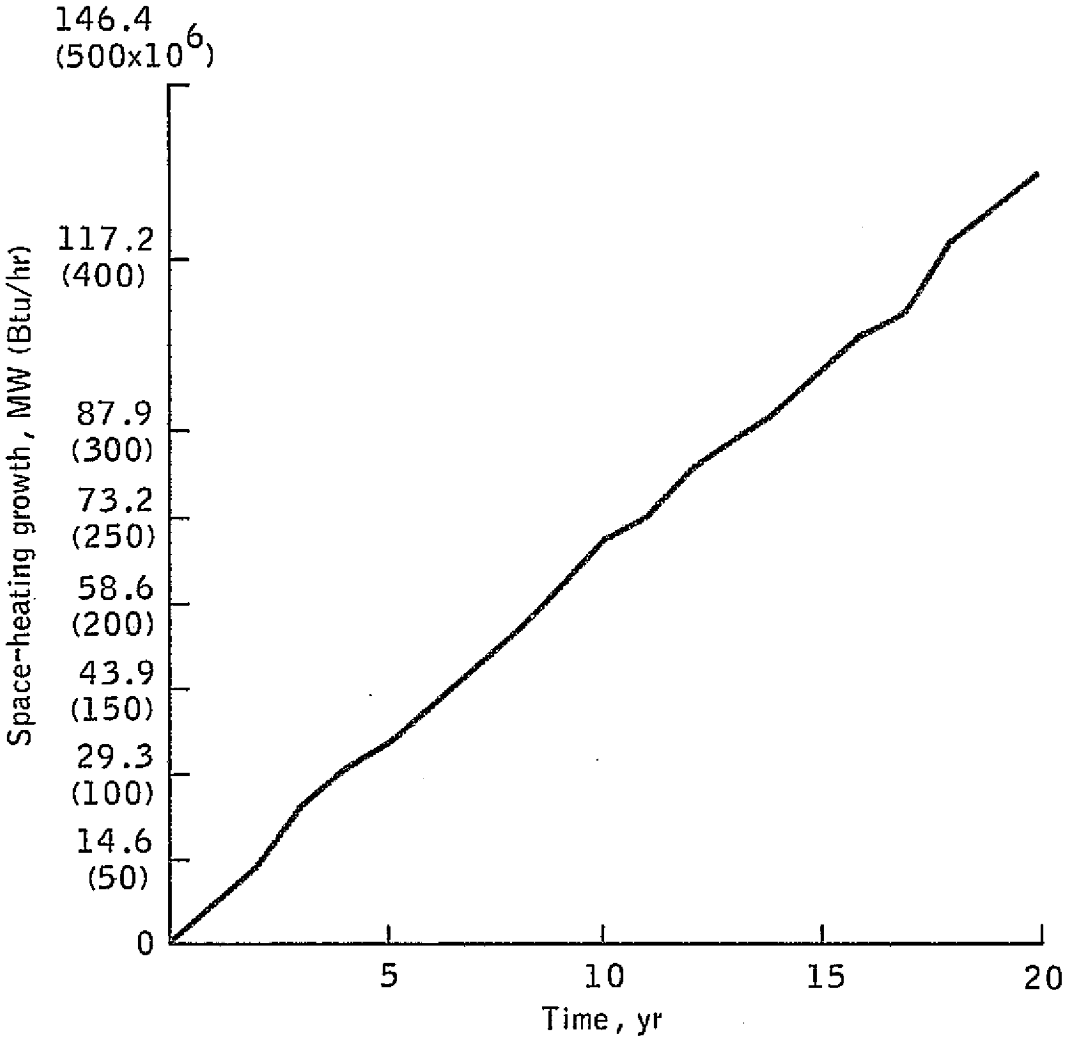


Figure B-9.- Total project space-heating growth; design case, 6 a.m.

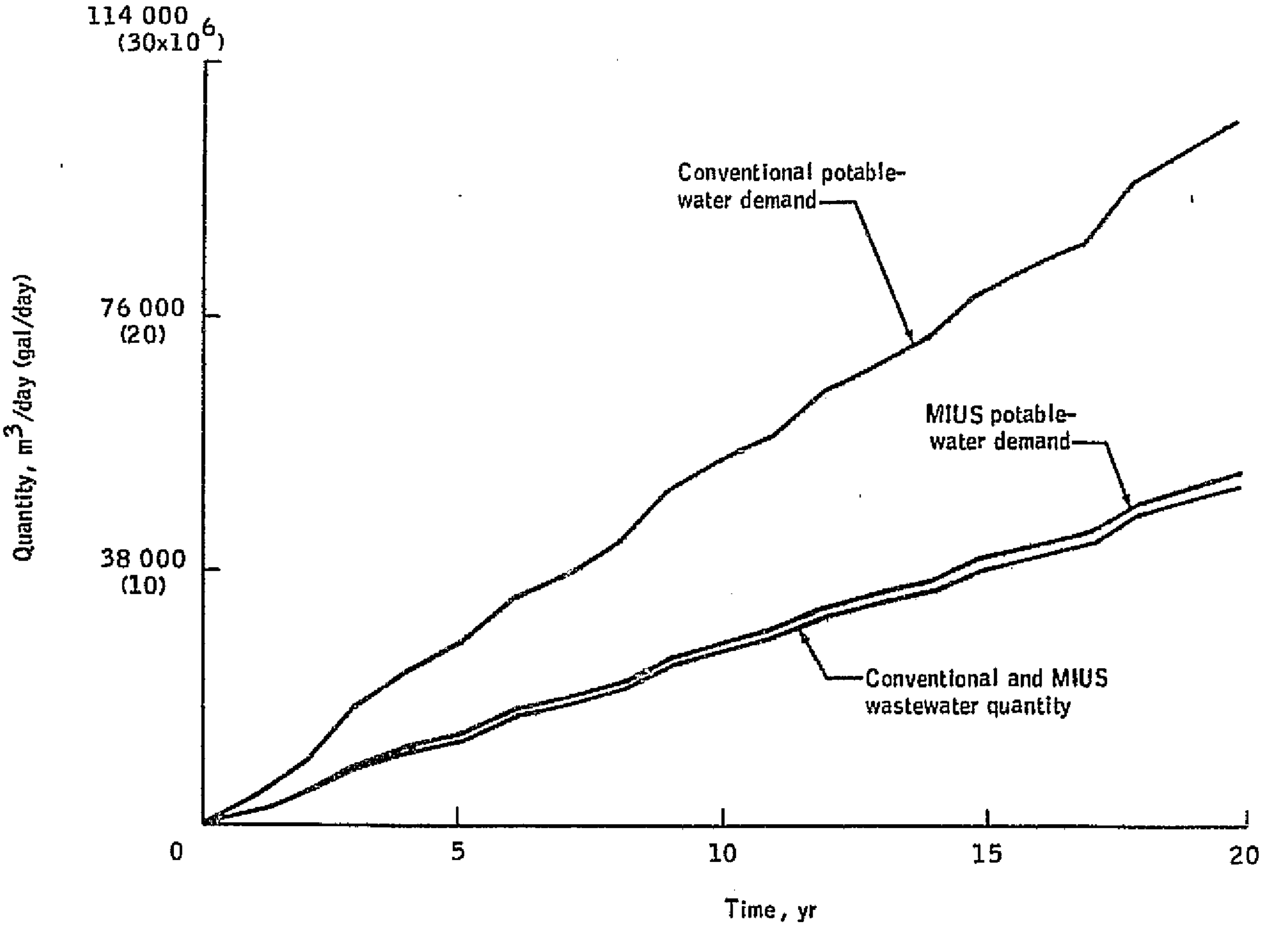


Figure B-10.- Community design load growth.

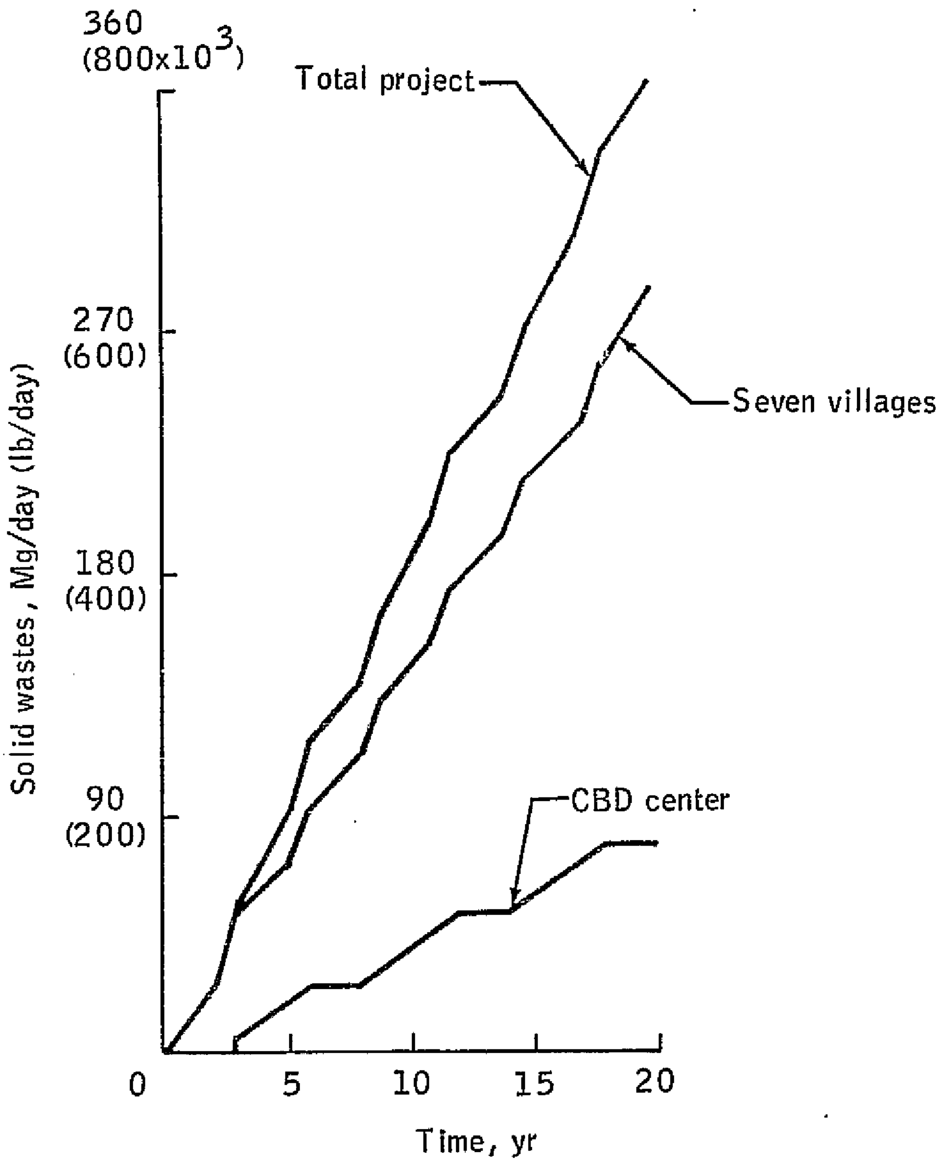


Figure B-11.- Solid waste loads.

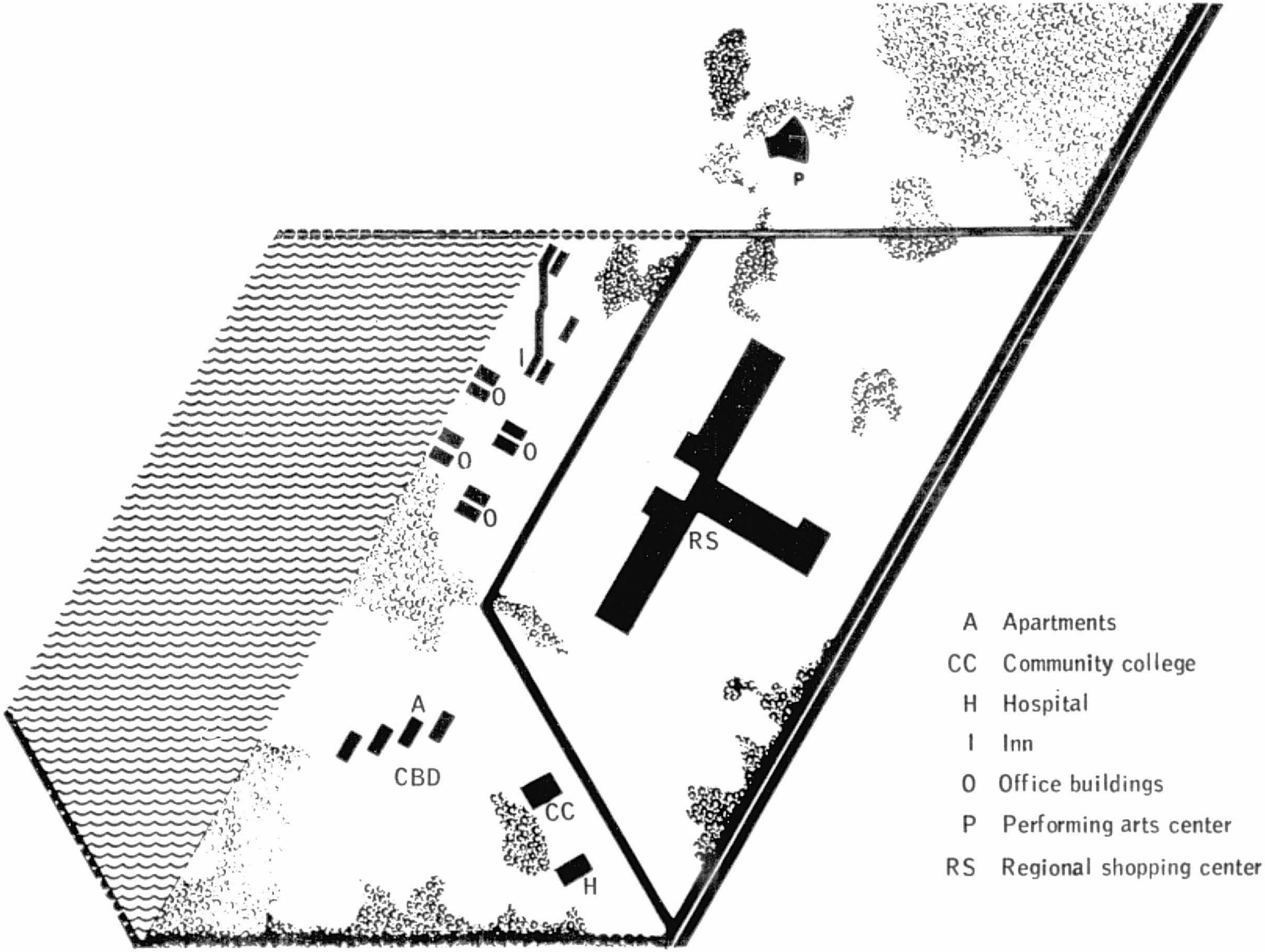


Figure B-12.- The CBD MIUS.

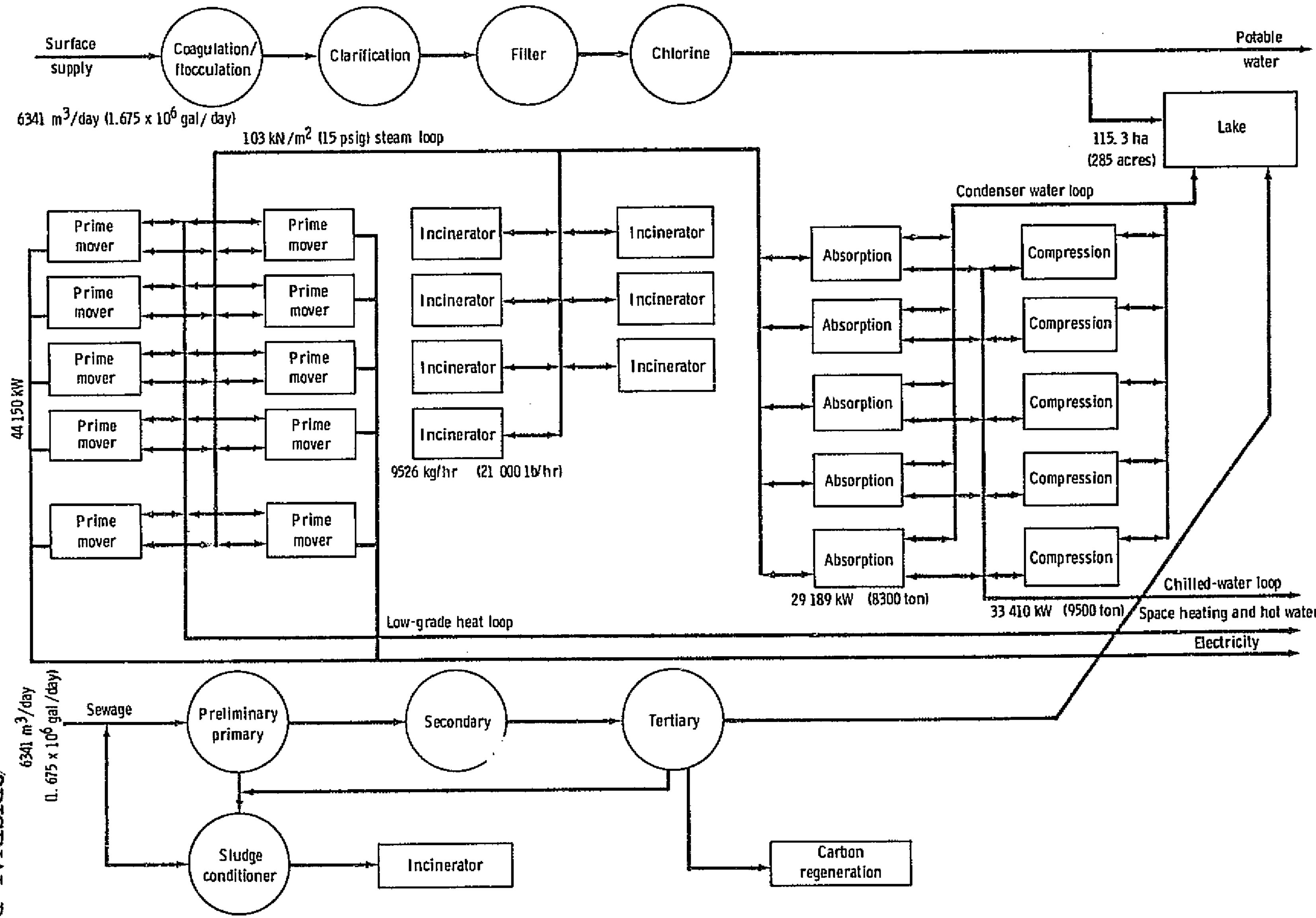


Figure B-13.- The CBD MIUS schematic.

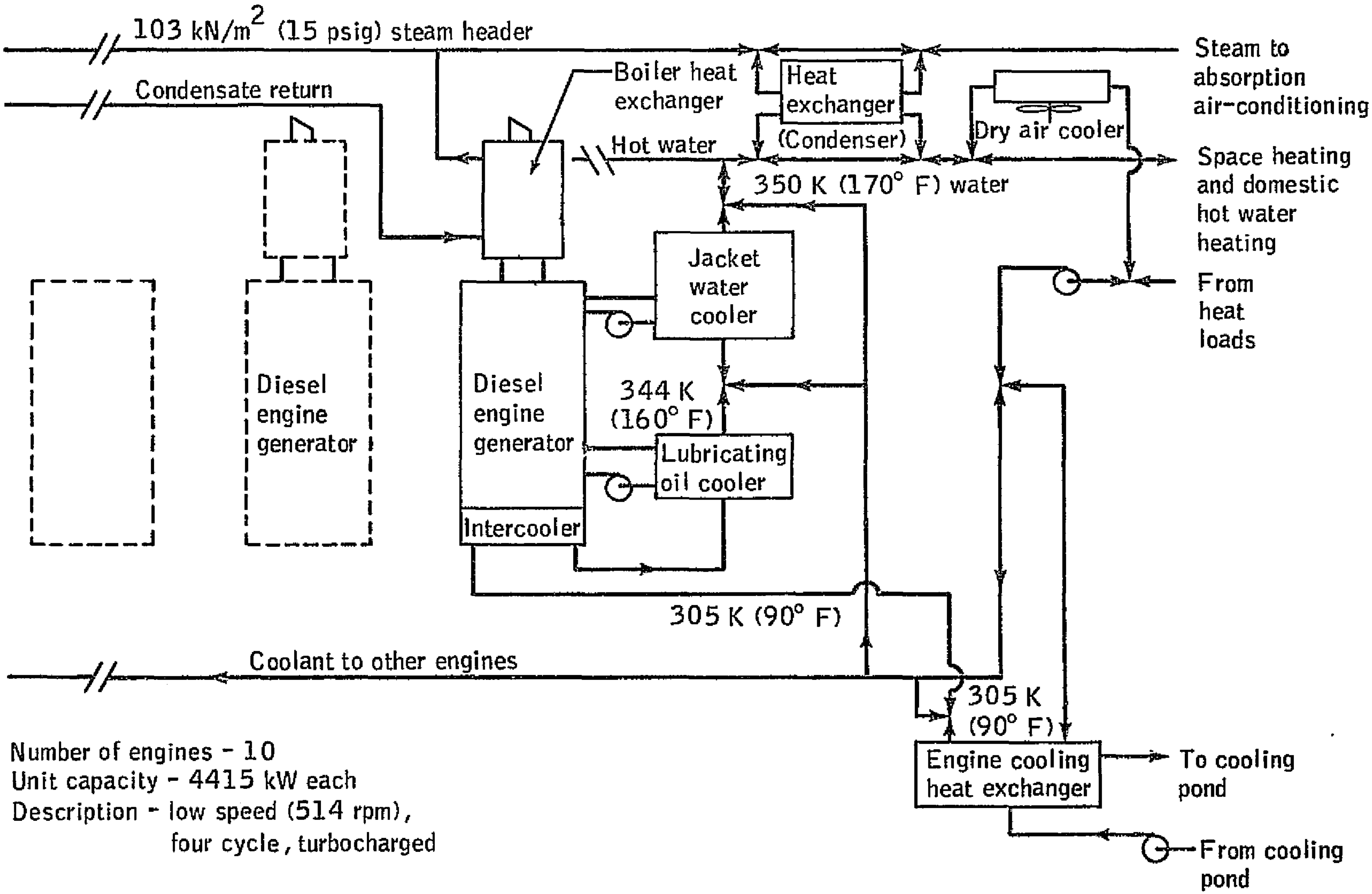


Figure B-14.- The CBD MIUS diesel-engine generator heat recovery and cooling schematic.

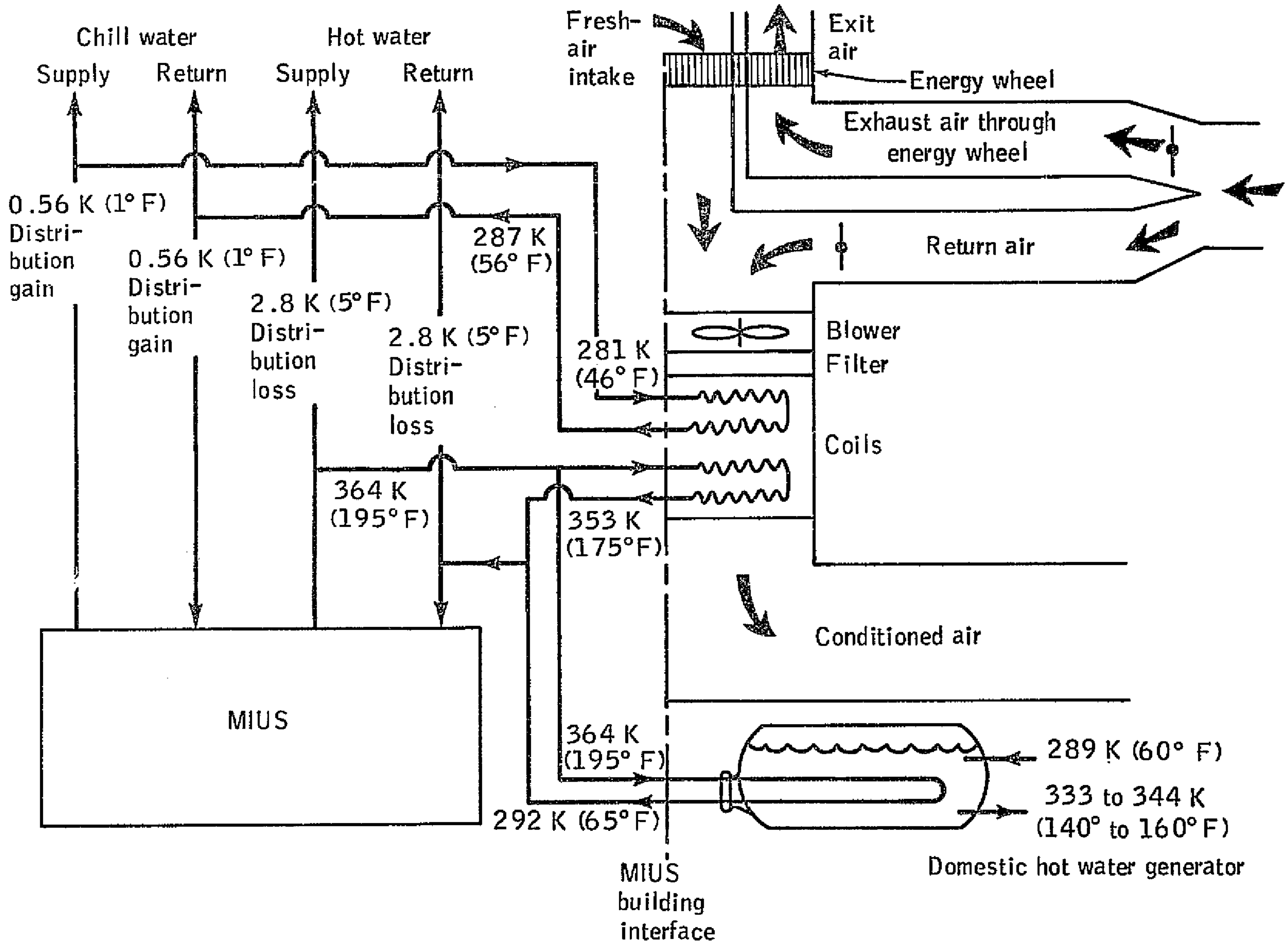


Figure B-15.- Typical MIUS HVAC system schematic.

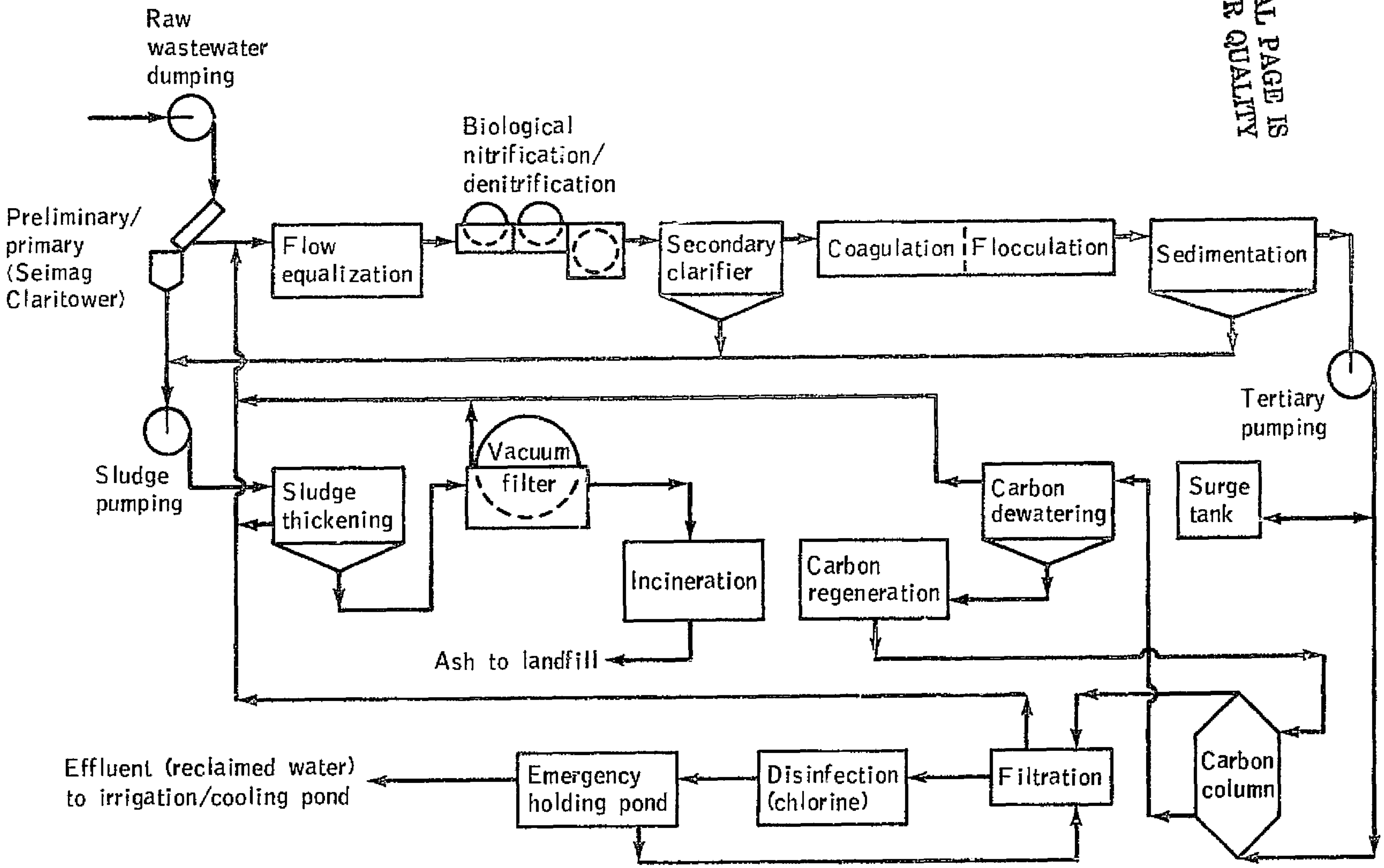


Figure B-16.- Waste management subsystem wastewater treatment plant schematic.

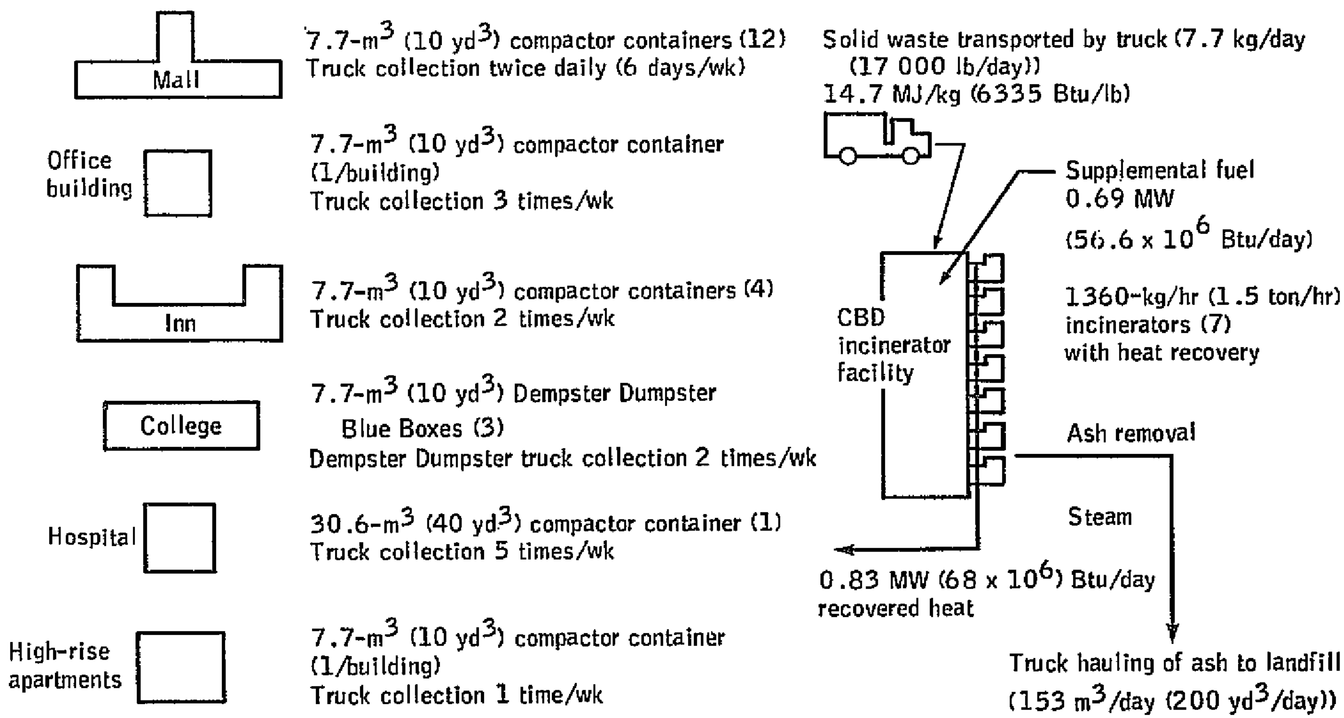


Figure B-17.- The CBD MIUS solid waste management subsystem.

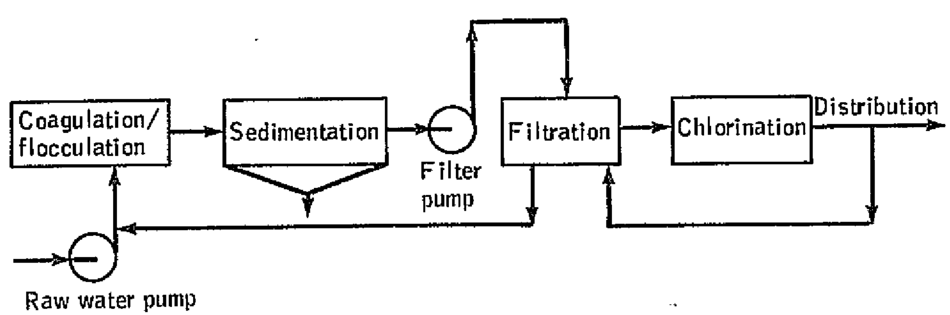


Figure B-18.- The waste management subsystem potable water treatment plant schematic.

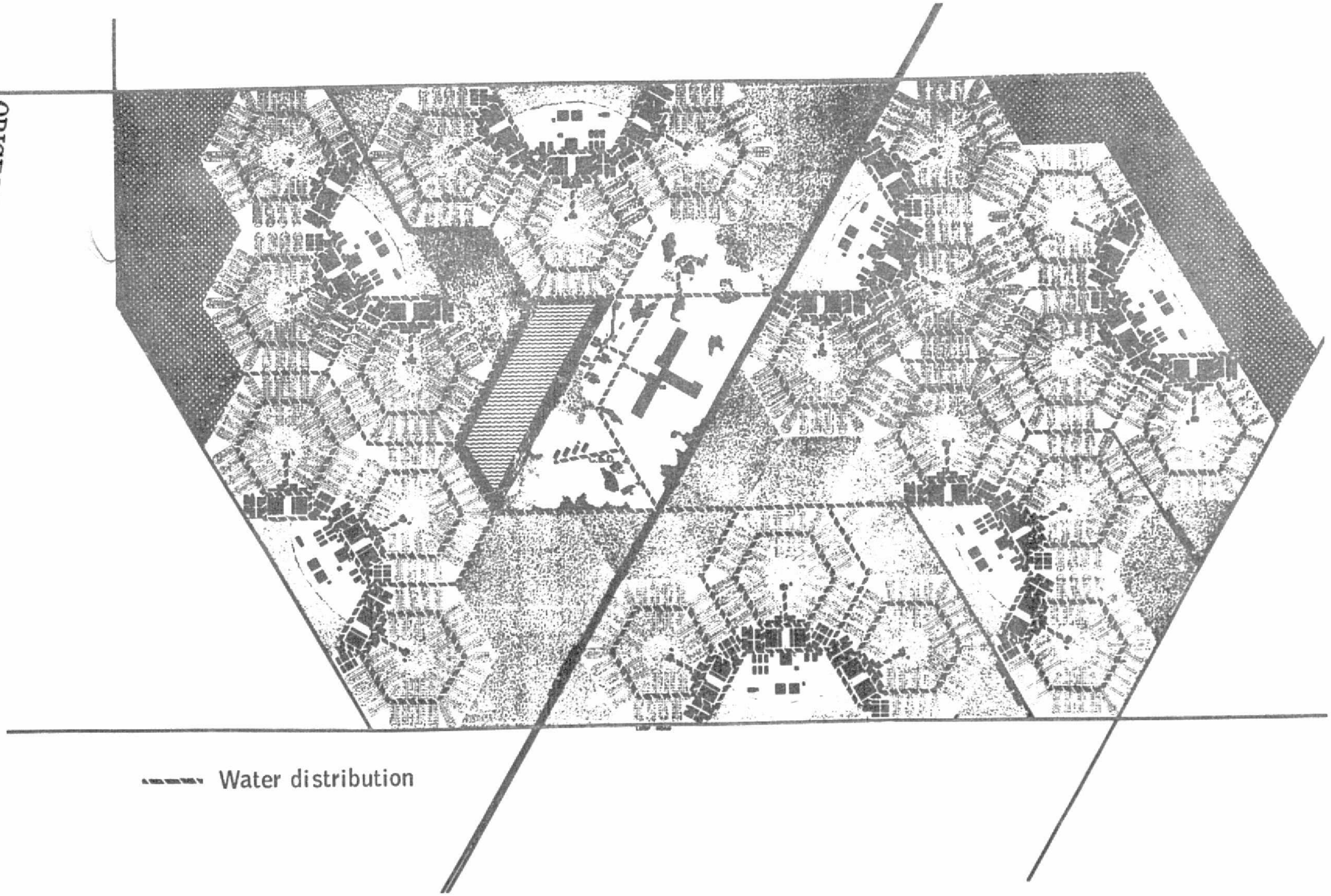


Figure B-19.- Conventional and option I water supply distribution.

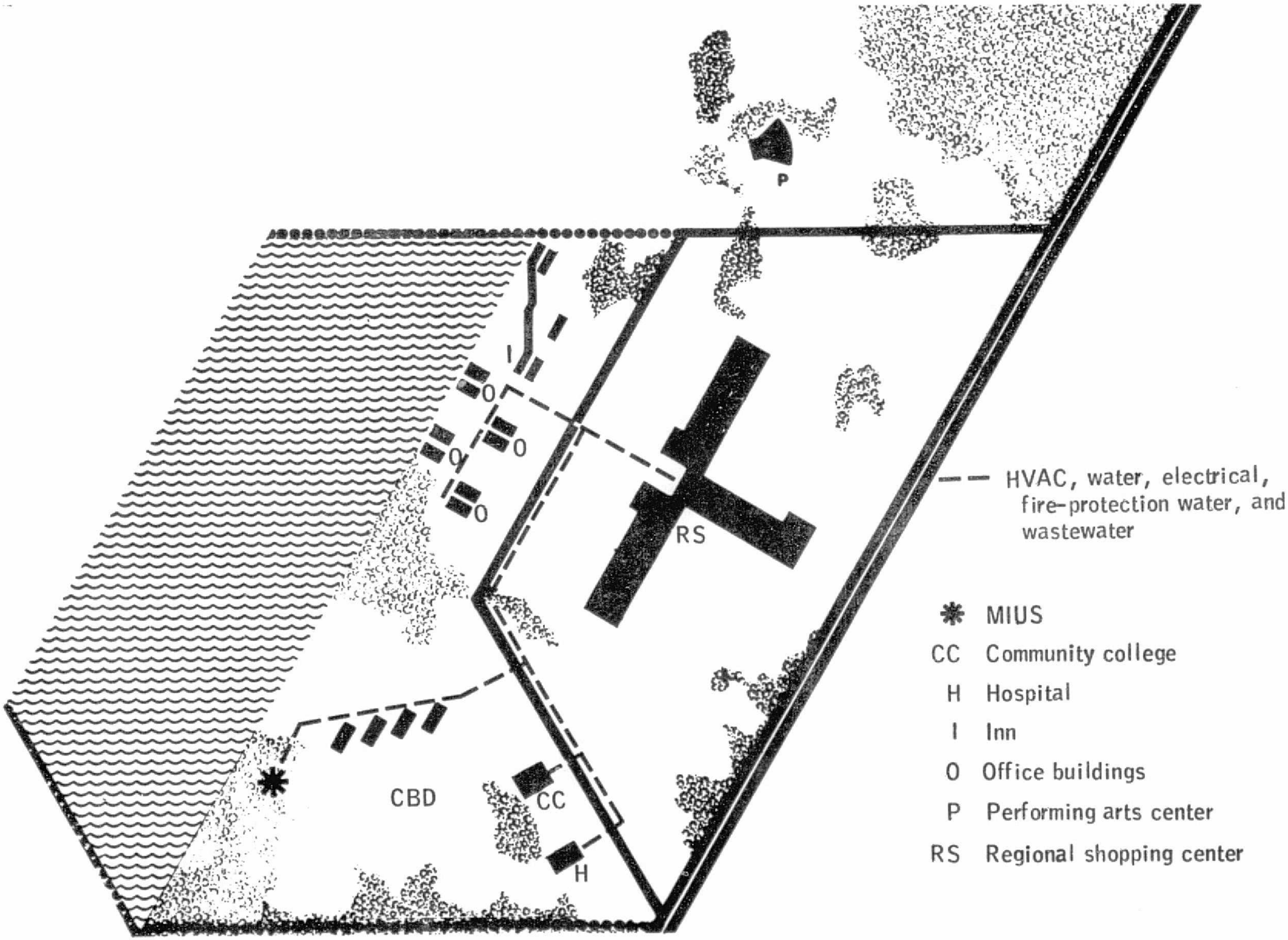


Figure B-20.- The CBD MIUS distribution system.

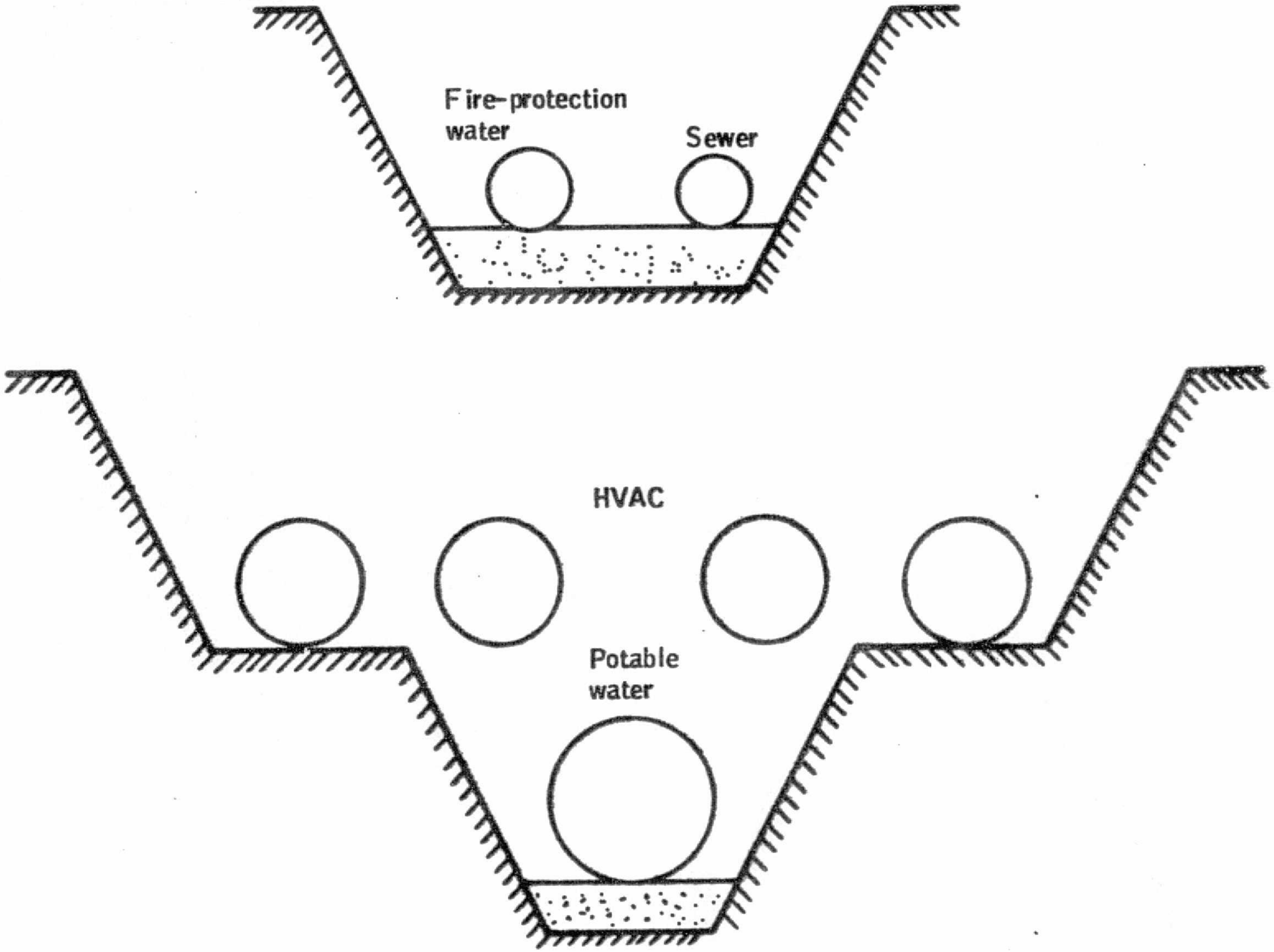


Figure B-21.- Distribution of community utilities for both design options.

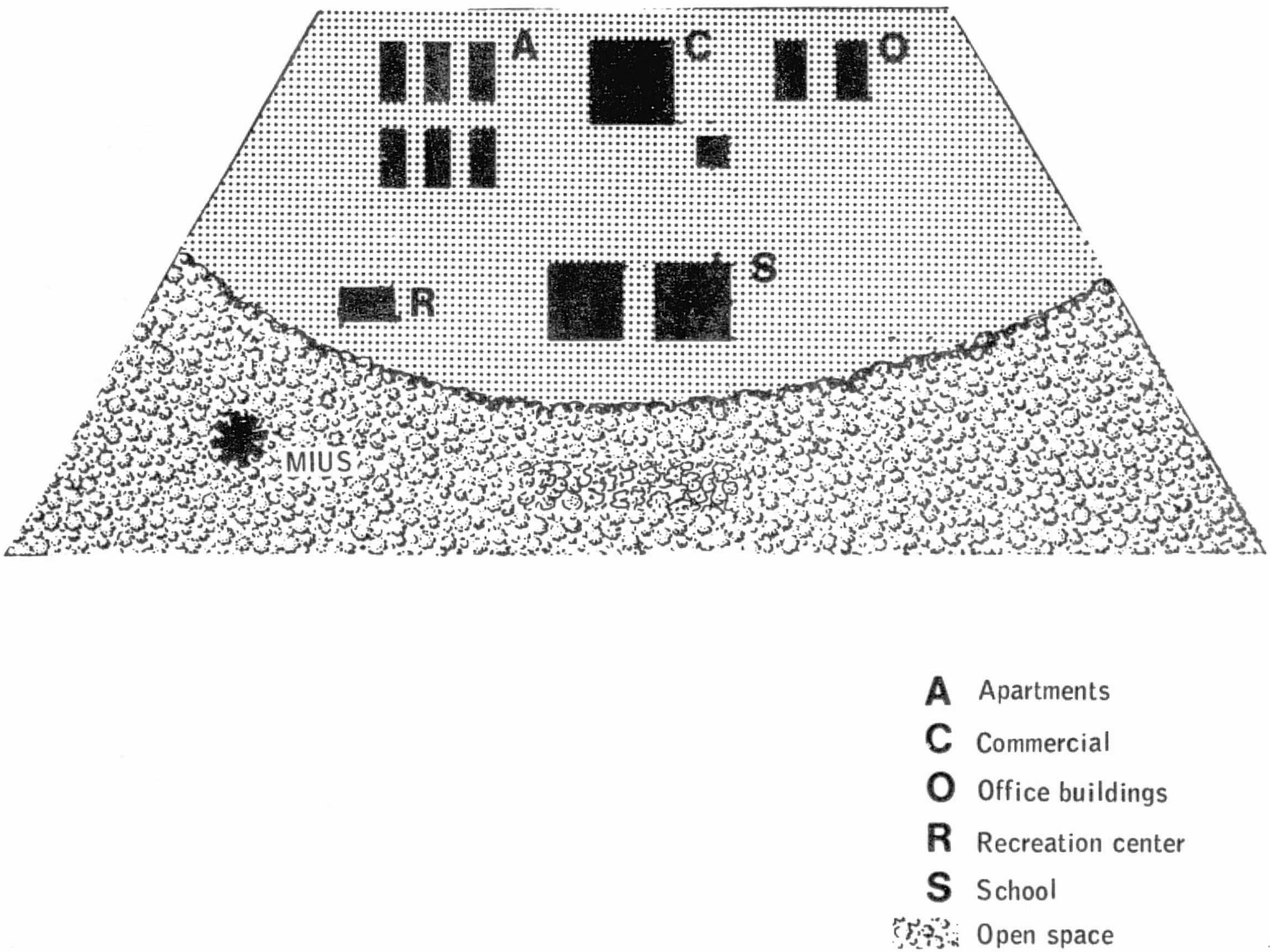


Figure B-22.- Village center MIUS.

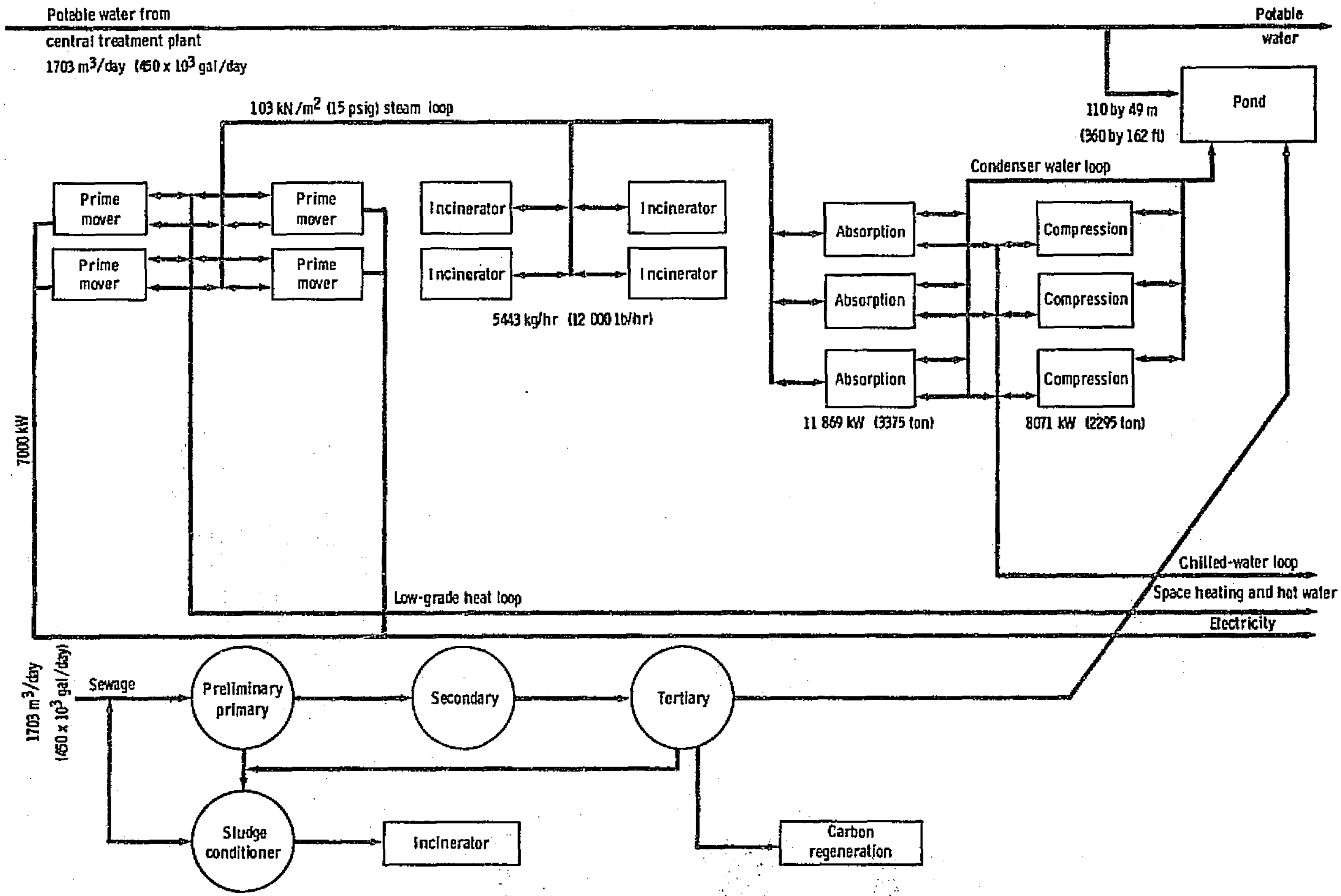


Figure B-23.- Village center MIUS schematic.

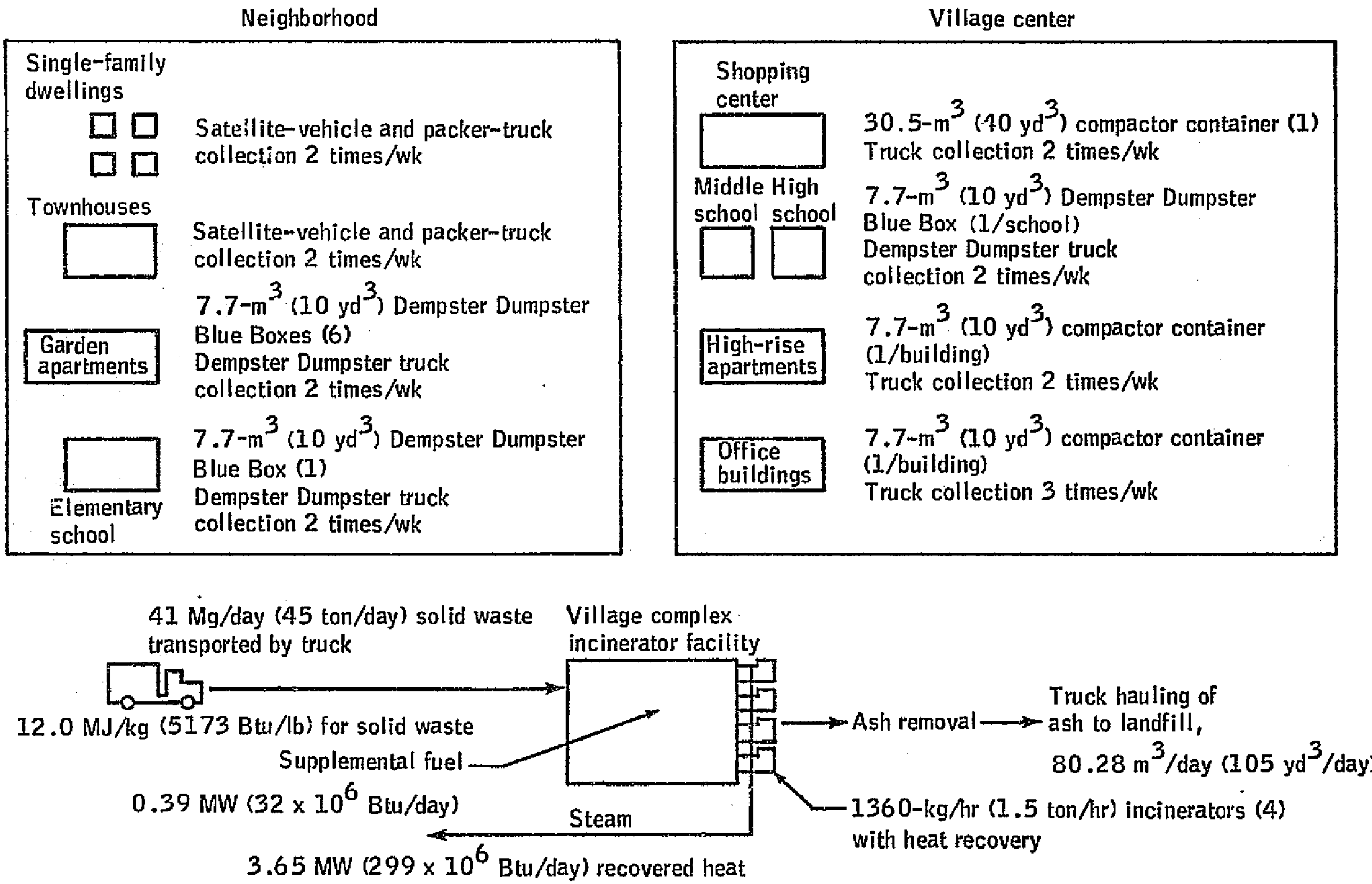
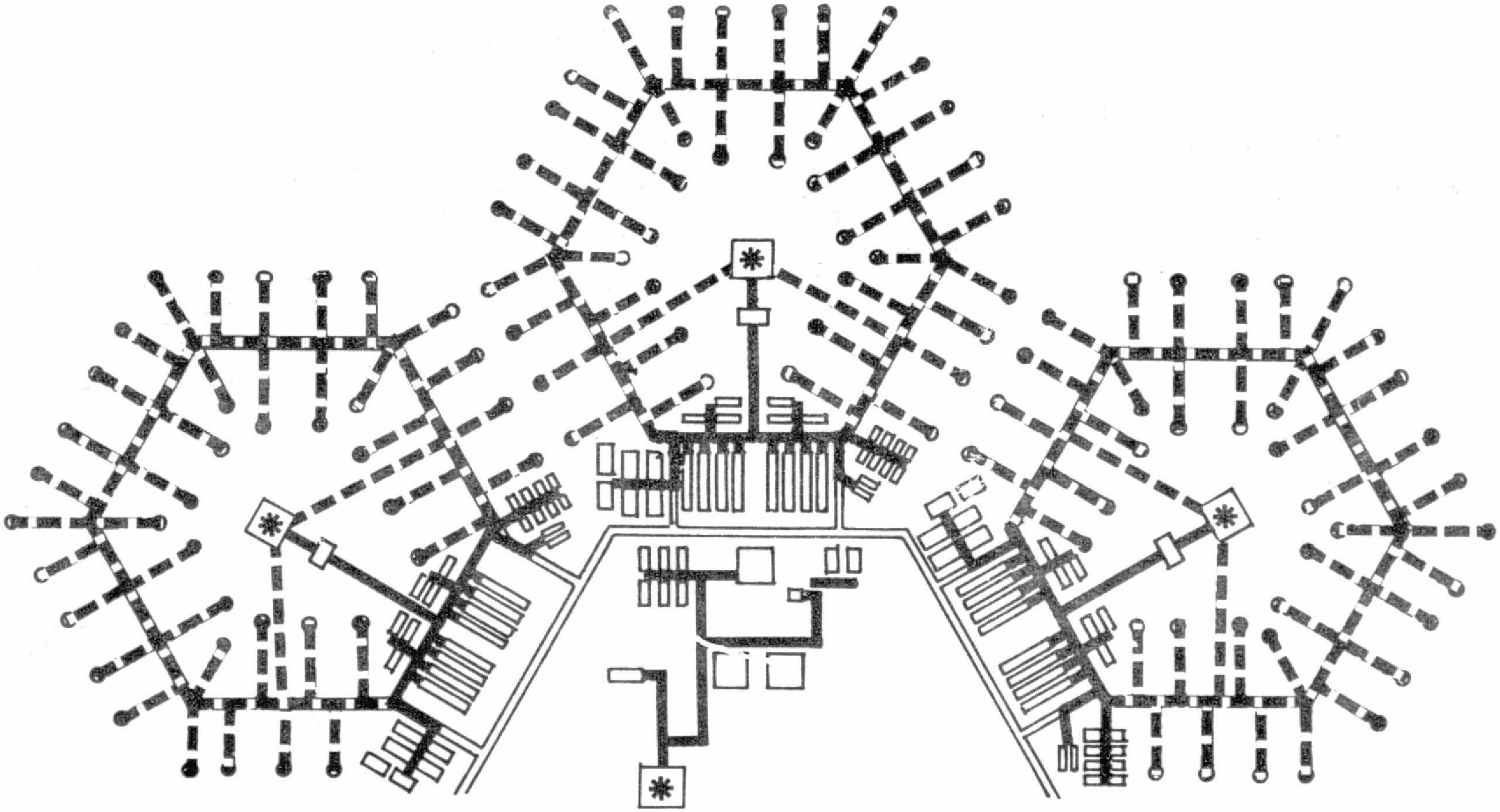


Figure B-24.- Village complex MIUS solid-waste management subsystem.



Village center HVAC, water, electrical, fire-protection water, and wastewater distribution systems

Neighborhood water, electrical, fire-protection water, and wastewater distribution systems

✱ MIUS

Figure B-25.- Neighborhood and village center option I distribution system.

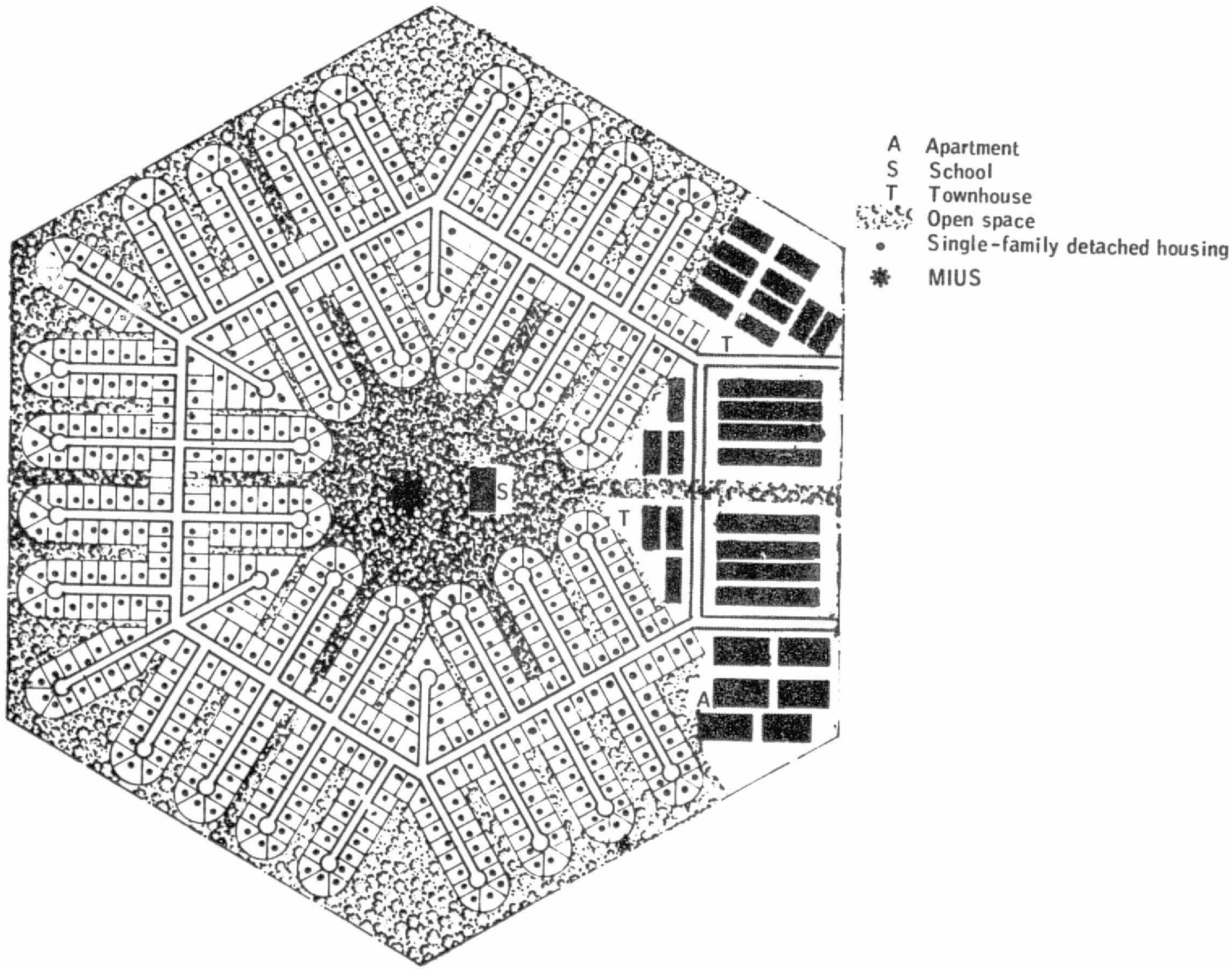


Figure B-26.- Neighborhood MIUS.

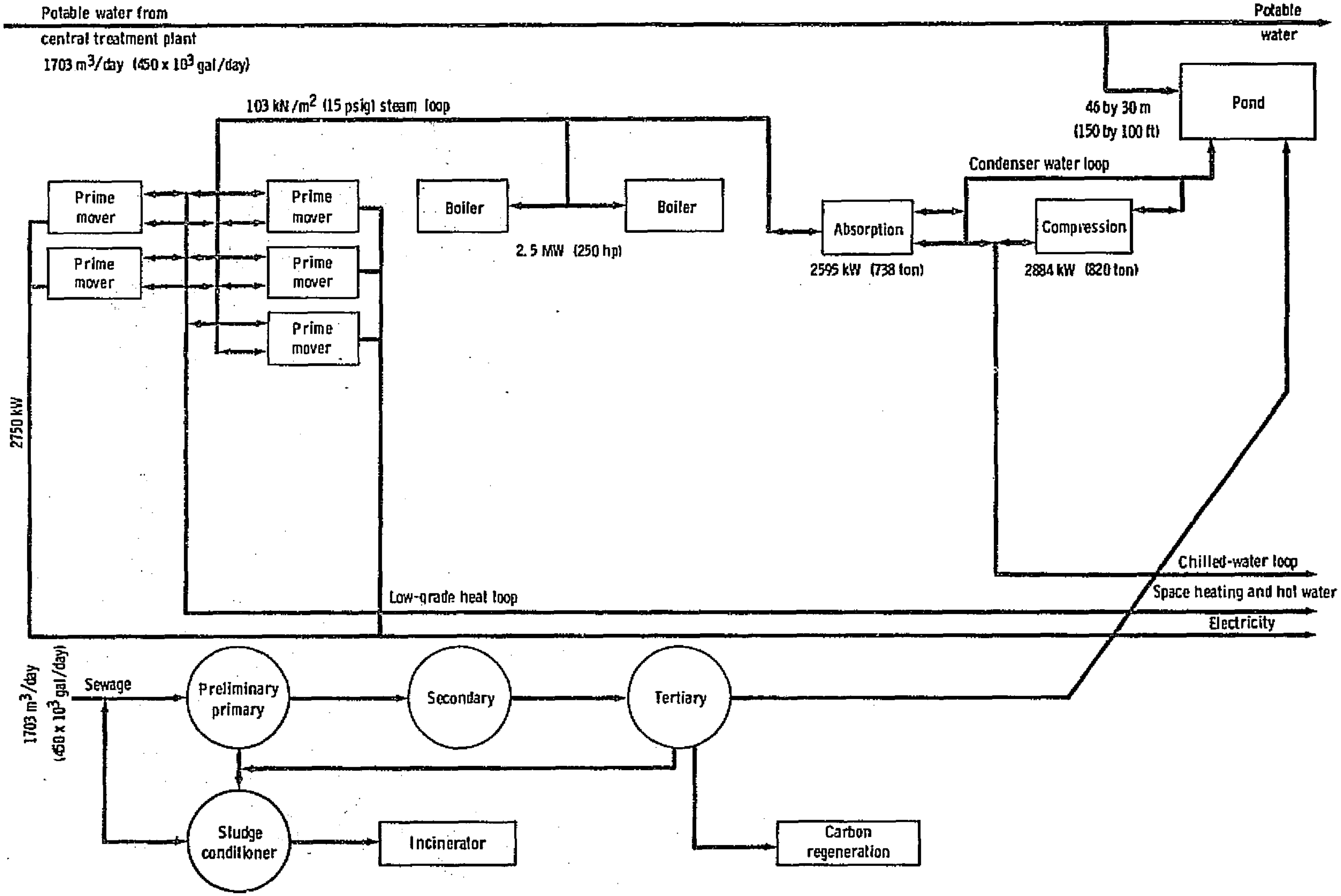


Figure B-27.- Neighborhood MIUS schematic.

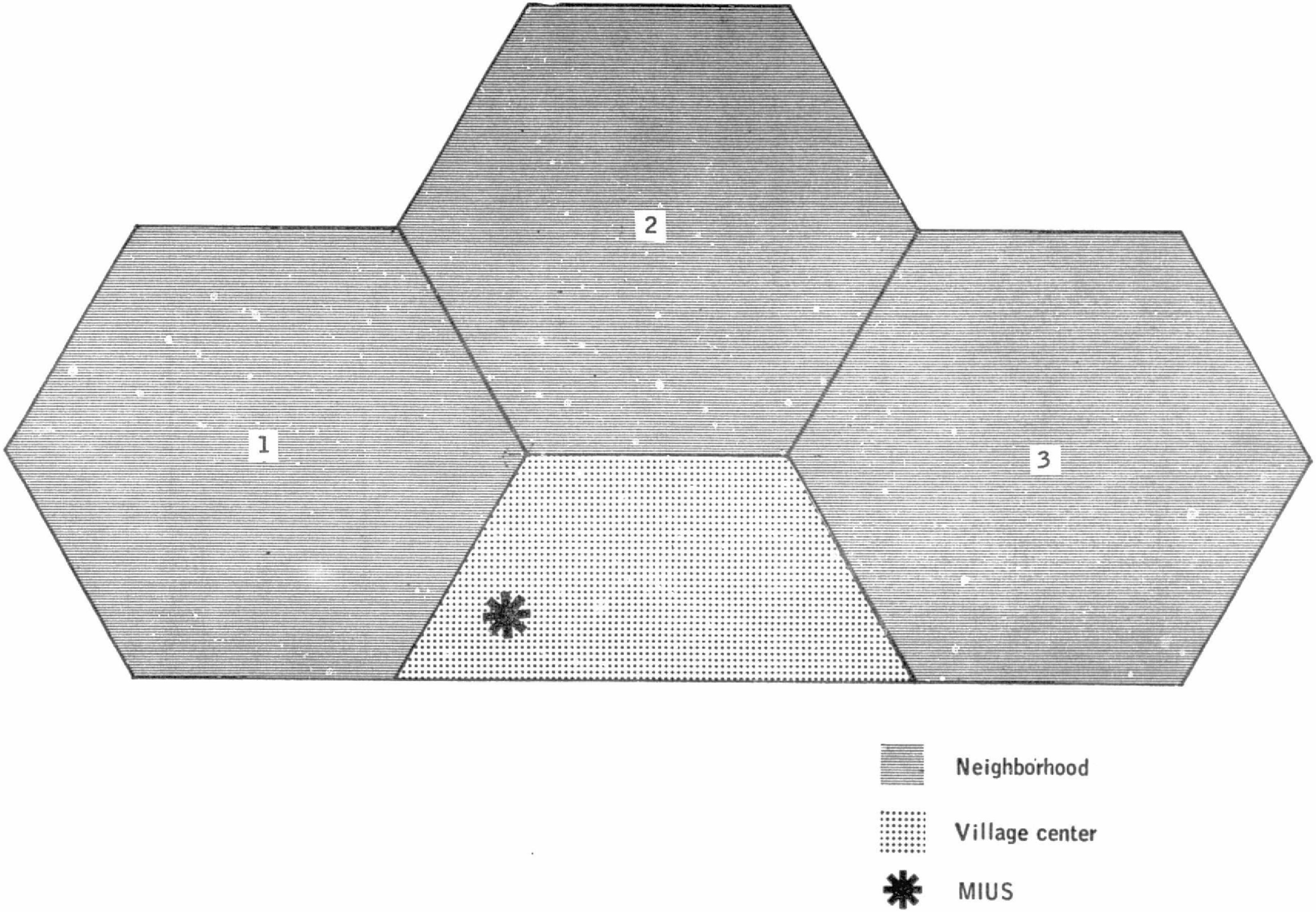


Figure B-28.- Village complex MIUS.

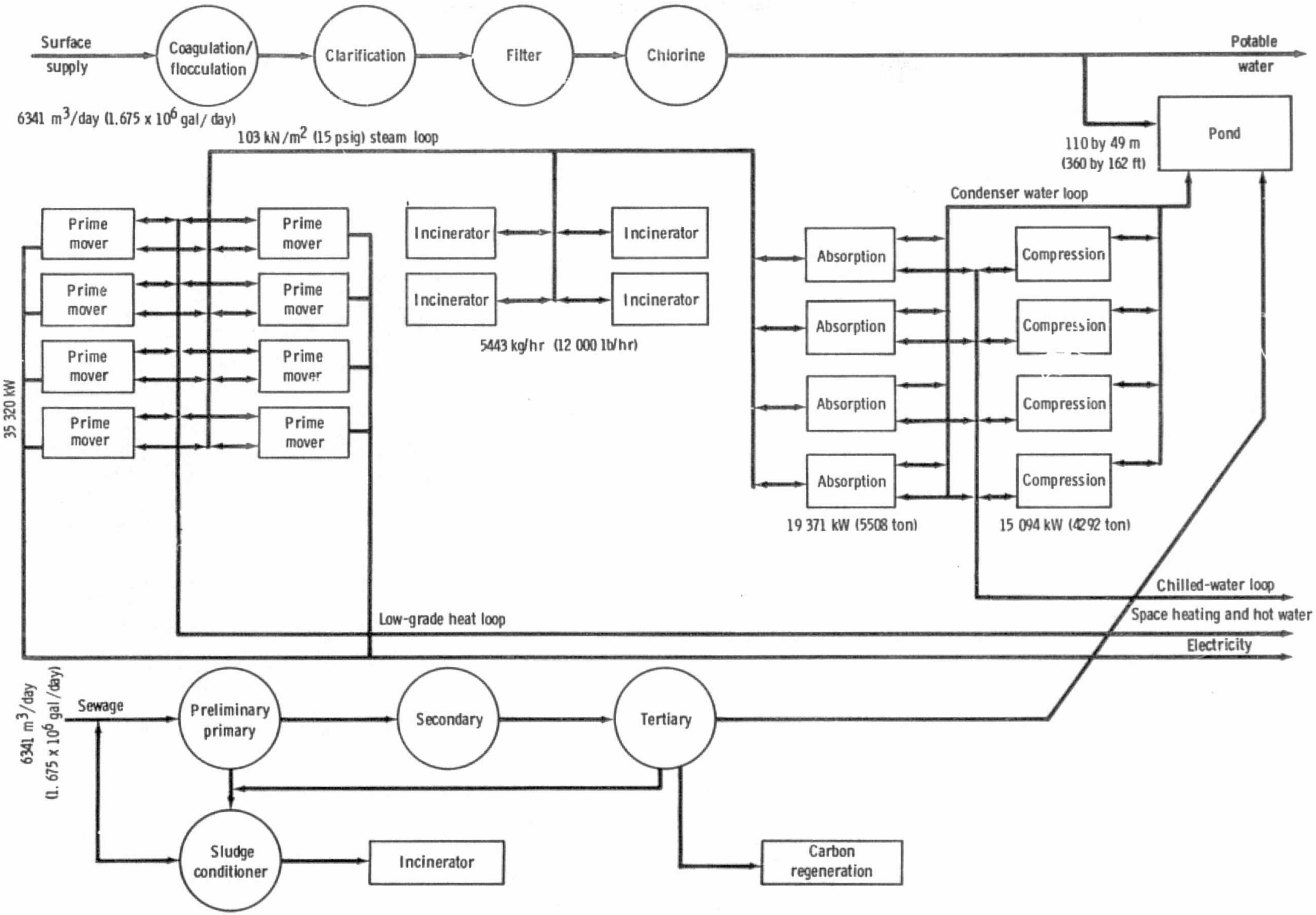


Figure B-29.- Village complex MIUS schematic.

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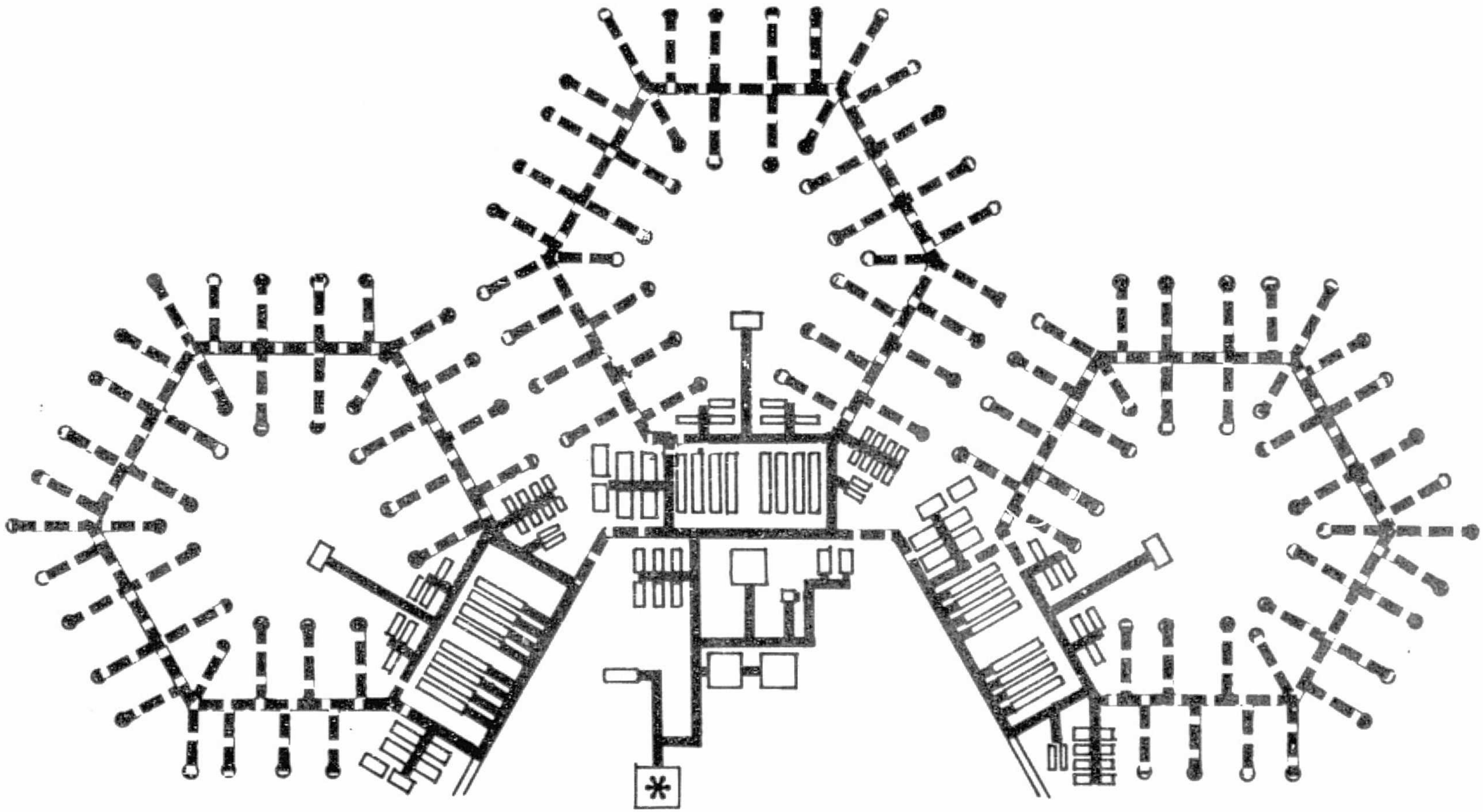


Village center HVAC, water, electrical, fire-protection water, and wastewater distribution systems

Neighborhood water, electrical, fire-protection water, and wastewater distribution systems

* MIUS

Figure B-30.- Neighborhood and village center option II distribution system.

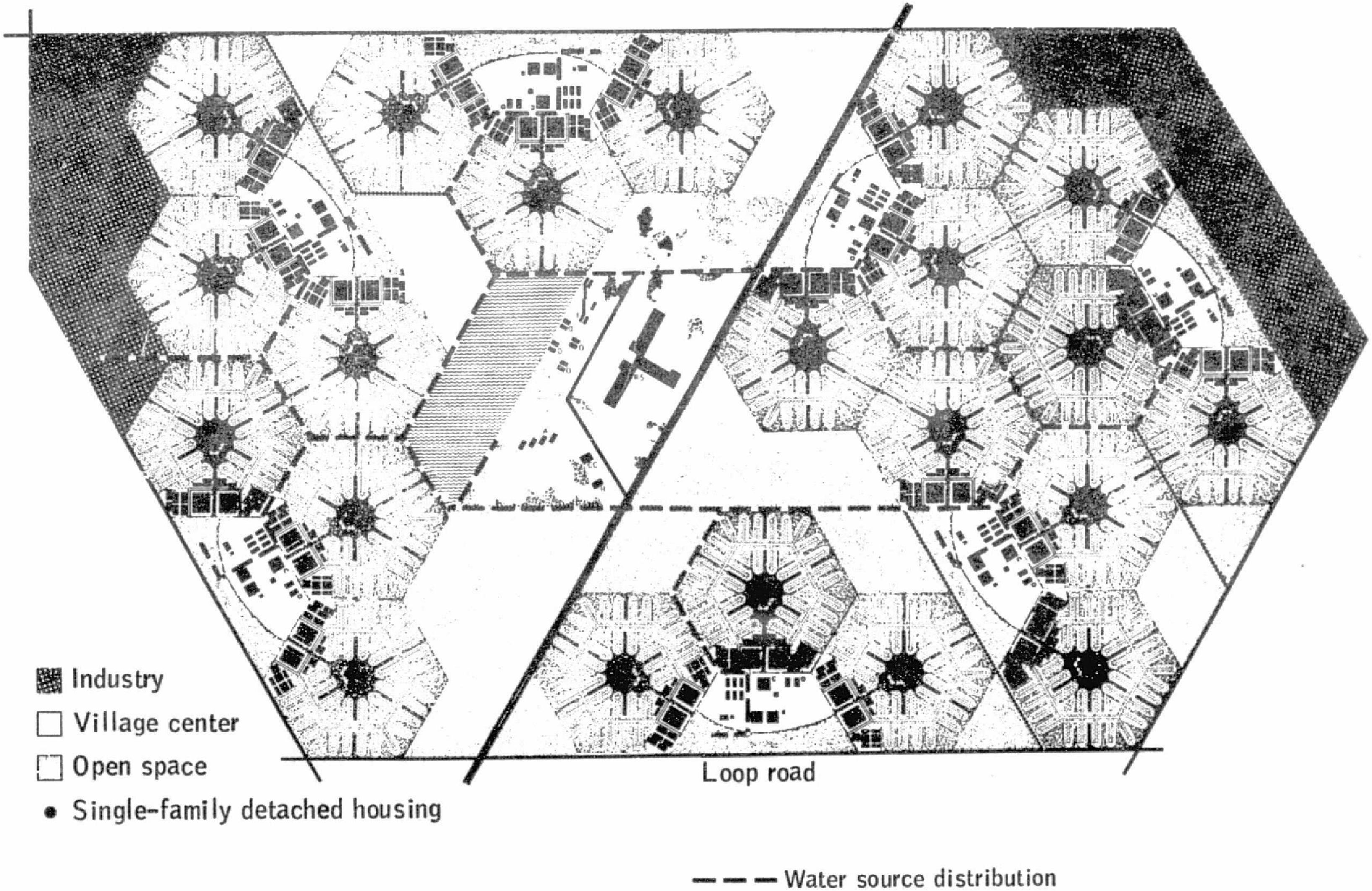


Figure B-31.- Option II water source distribution.

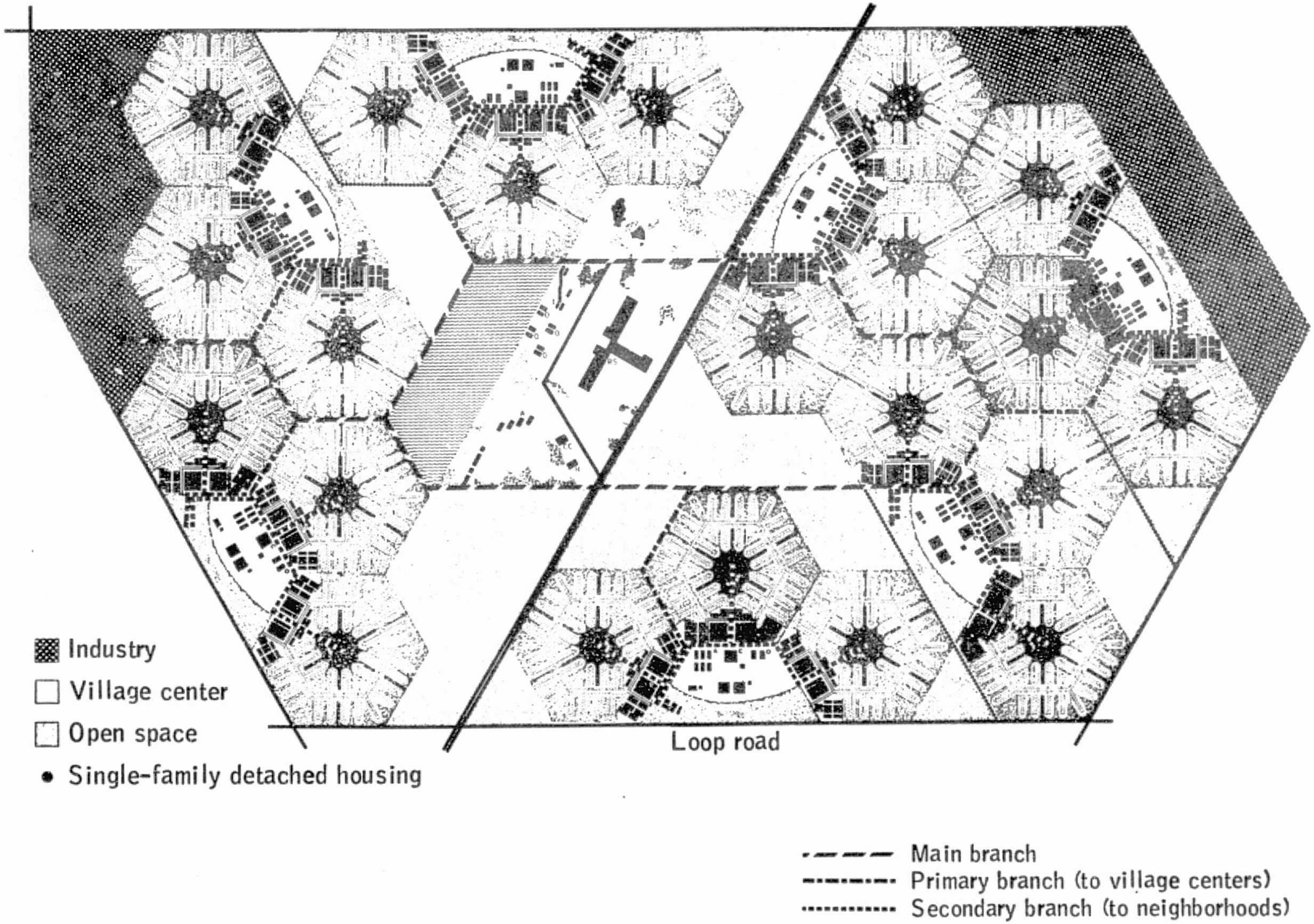
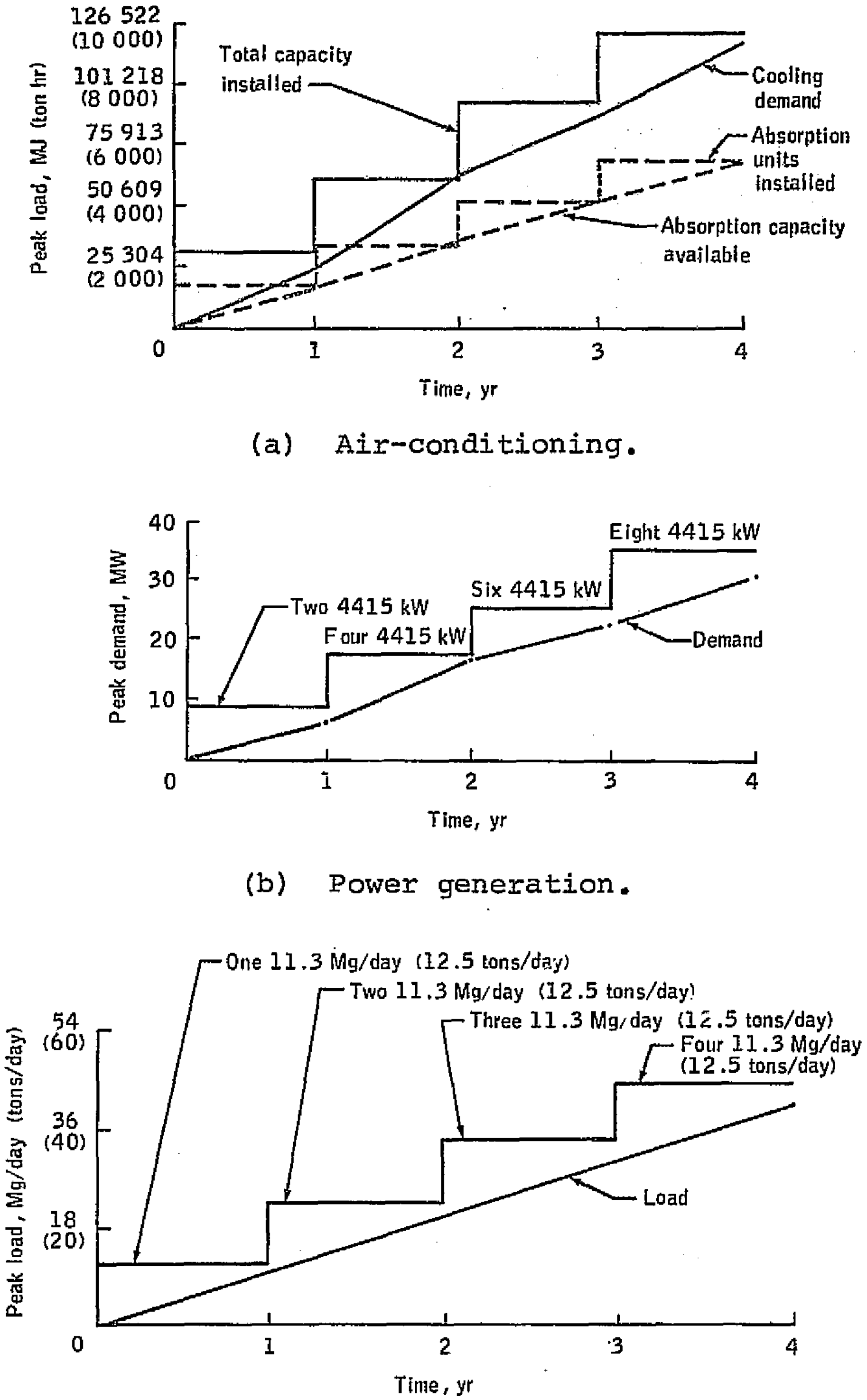


Figure B-32.- Fuel oil distribution system for MIUS.



(a) Air-conditioning.

(b) Power generation.

(c) Solid waste incineration.

Figure B-33.- Typical MIUS subsystems installation schedule for a village complex built over a 4-year period.

APPENDIX C

COMMUNITY ENERGY ANALYSIS SUPPORTIVE DATA

ESOP ANALYSIS

The Energy System Optimization Program (ESOP) was first used to determine peak equipment loads for equipment sizing. This determination was made by performing analyses for the summer and winter seasons using hourly weather data (which are two standard deviations above and below the mean, respectively) for the Washington, D.C., area. The data for January were used for the winter season and July data were used for the summer season.

After the design loads were determined, preliminary prime mover selections were made and were used for subsequent energy analyses with mean weather data. Mean data for January, April, July, and October were used, respectively, for winter, spring, summer, and fall seasonal analyses.

COMMUNITY ELEMENT DATA

A complete set of data for each community element at the end of its development period is given in figures C-1 to C-29. Each set of data consists of a summary comparison of the MIUS to a conventional utility system on an annual basis, a bar chart showing MIUS seasonal fuel consumption, a set of energy utilization charts showing both annual and seasonal energy flows for the various services provided by the MIUS, charts showing the MIUS seasonal thermal efficiency and percent of total heat utilized, and a set of curves showing hourly heat availability and utilization for both high- and low-grade heat for the winter and summer seasons. This information is included for each of the community elements: neighborhood, village center, village complex, and central business district (CBD). The CBD is common to both the 29-MIUS option (option I) and 8-MIUS option (option II), whereas the neighborhood and village center data apply only to option I and the village complex data apply only to option II.

In both options, trash incineration at the village centers included trash for the three associated neighborhoods. This fact is evident in all the energy utilization data. All the comparisons between MIUS and conventional energy requirements were made with the conventional configuration that uses electrical strip heaters for space heating in the townhouses and garden apartments rather than unitary heat pumps. These comparisons were made for consistency because the conventional system that was defined for cost comparisons included strip heating. In every instance, the single-family dwellings used individual unitary heat pumps for air-conditioning and space heating. A bar chart that shows an energy comparison to both conventional configurations is included in those figures presenting total community data.

The annual energy utilization bar charts show a summary of the MIUS energy input and the relative amount of energy used by each of the services provided by the MIUS. The energy utilization flow charts indicate, in more detail than the annual bar charts, the energy input and energy utilization. The flow charts are included for both annual and seasonal totals and show the temperature level of waste heat utilized for each service, the amount of electricity used for air-conditioning, and the amount of unused waste heat. A guide for interpreting the energy utilization flow charts is shown in figure C-1.

The heat availability and utilization curves present hourly data based on seasonal average weather conditions for each community element for both high- and low-grade heat. Low-grade heat is defined as the heat available from the engine water jackets and oil coolers and is used for domestic hot water heating and for space heating. High-grade heat is the heat available from the engine exhaust and incineration and is used to satisfy any low-grade heat requirement not satisfied by low-grade heat and for operation of the absorption chillers. The point at which the lines on the curves coincide represents the time when the demand for either grade of heat equals or exceeds the available heat. Thus, on the high-grade heat curves, any point at which the lines coincide represents a time when compression chillers are being operated to satisfy the air-conditioning demand. The resulting available heat shown includes that which is available because of generation of electrical power required by the compression chillers.

CONVENTIONAL DATA

Energy utilization data and fuel consumption data for a conventional utility system are presented in figures C-30 and C-31 for each of the community elements and for the completed community at the end of the 20-year development period. The data reflect the energy consumption for the conventional system, which uses strip heaters for space heating in the garden apartments and townhouses.

THE MIUS DATA FOR THE 20TH YEAR

Energy utilization data and fuel consumption data are presented in figures C-32 to C-43 for the total community served by the MIUS at the end of the 20-year development period. A complete set of data is presented for both option I and option II.

Included for each option are a summary comparison of a conventional utility system, bar charts showing MIUS annual fuel consumption, annual fuel savings as compared to both conventional configurations (strip heating and heat pumps), MIUS seasonal thermal efficiency, and MIUS annual energy utilization. Also included are annual and seasonal flow charts showing the sources and utilization of energy for the various services provided by the MIUS.

DATA FOR THE 4TH- AND 10TH-YEAR GROWTH POINTS

Energy analysis data for the 4th and 10th years of the 20-year development period of the community are presented in figures C-44 to C-70. For the 4th- and 10th-year points, the neighborhood, village center, and village complex analyses are virtually identical except for the multiples of the typical community elements completed. At the end of the 4th year, one village center and the three associated neighborhoods are complete, and 2 years of a 4-year development are completed on the second village center/neighborhood complex. At the end of the 10th year, the same configuration exists except that three village center/neighborhood complexes are completed. Because the CBD is not developed in identical phases, it was analyzed separately for the two growth points.

Figures C-44 to C-47 and C-58 present the energy utilization for each community element, which is different from previously presented data. The data for the

neighborhood, village center, and village complex for the 4th year also apply to the 10th year, whereas the data for the CBD is presented for both growth points.

Figures C-48(a) and C-59(a) show the fuel consumption for the conventional utility system that is required to satisfy the same loads used for MIUS analyses. The conventional configuration uses electric strip heaters for space heating in the townhouses and garden apartments.

Figures C-48(b) to C-57 and C-59(b) to C-68 present the energy analysis data for option II and option I in a format similar to that used for the 20th-year analysis.

COMMUNITY GROWTH SUMMARY

A summary of fuel consumption, energy savings, and thermal efficiency during the development period is presented in figures C-69 and C-70 for the two MIUS community options. Figure C-69 shows annual fuel consumption and energy savings for each year in the development period. Points other than the 4th, 10th, and 20th year are based on extrapolations of the yearly electrical loads throughout the development period. No detailed energy analyses were performed using the ESOP computer program for the intermediate points; however, the data presented should be indicative because electrical load is the major drive in fuel consumption. Figure C-70 shows thermal efficiency and the percent of heat utilized for both options at the three growth points analyzed.

The comparison between option I and option II shows very little difference in fuel consumption for the entire community throughout the development period. When the two options are compared with a conventional utility system, option II shows slightly more than 38 percent energy savings and option I shows slightly less than 38 percent energy savings. The same relative relationship exists for all growth points considered.

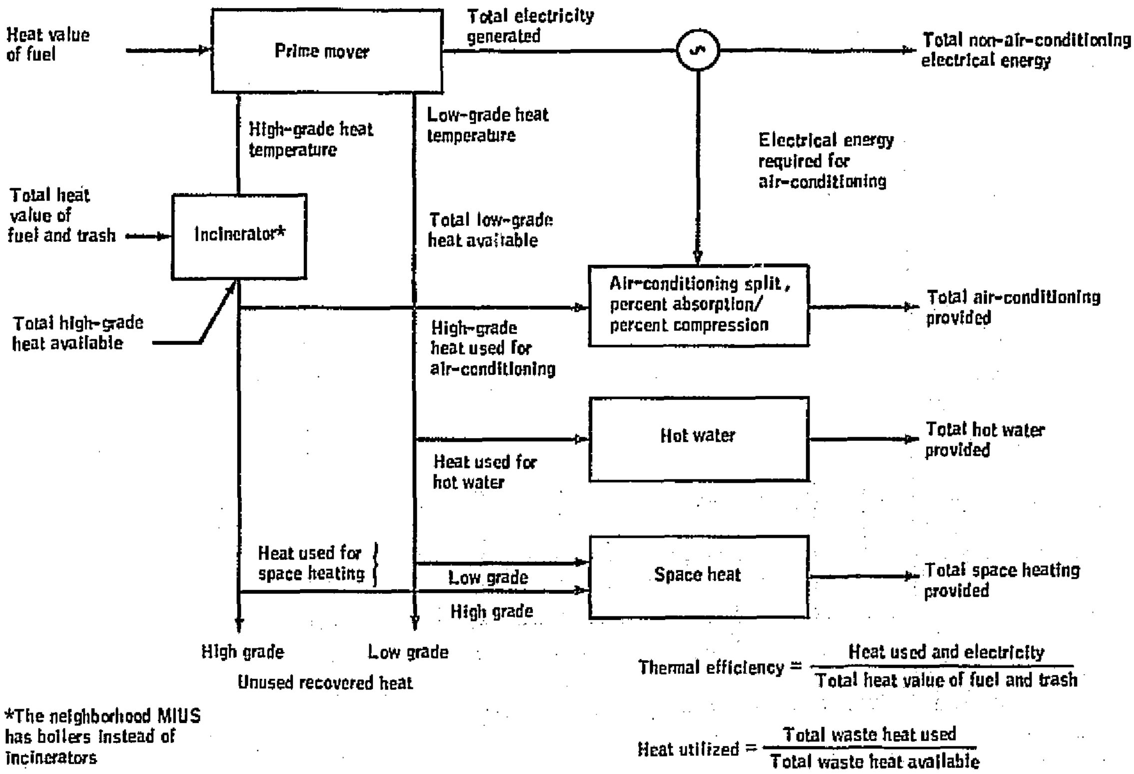
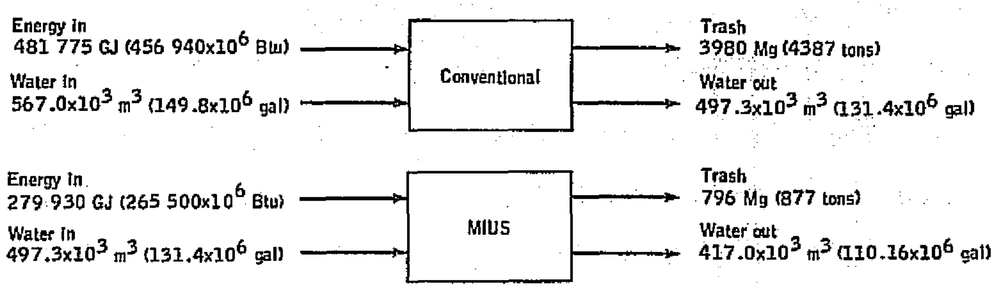


Figure C-1.- Explanation of derivation of values for energy utilization flow charts.



Category	Savings, percent
Water savings	12.3
Effluent reduction	16.2
Trash load reduction	80.0
Energy savings	
Winter	49.3
Spring	40.1
Summer	32.3
Fall	38.9
Annual	41.9

Figure C-2.- Comparison of annual figures for a neighborhood MIUS and a conventional system.

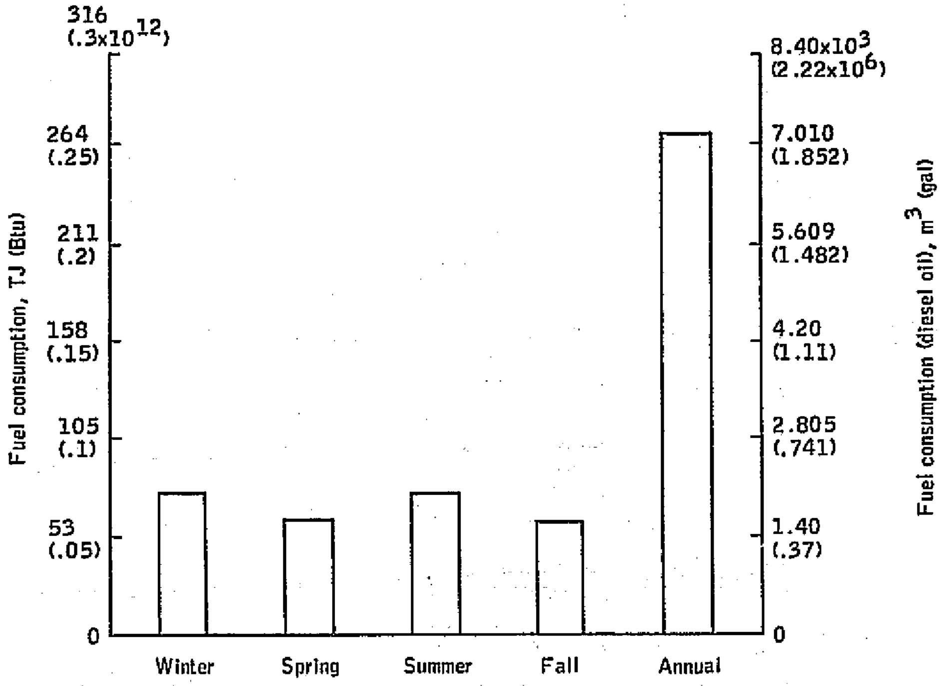


Figure C-3.- Neighborhood MIUS fuel consumption.

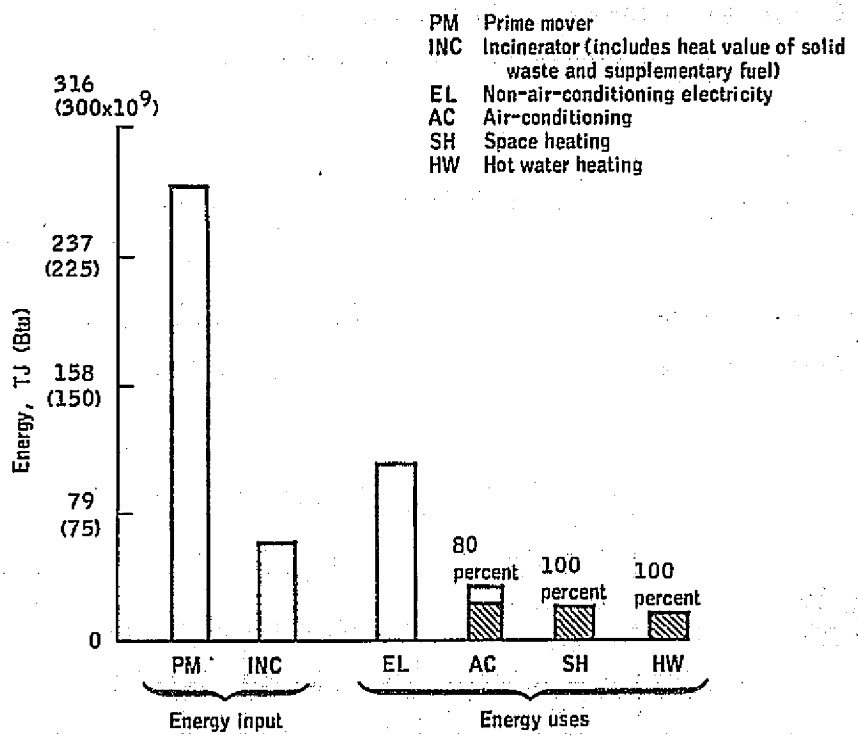
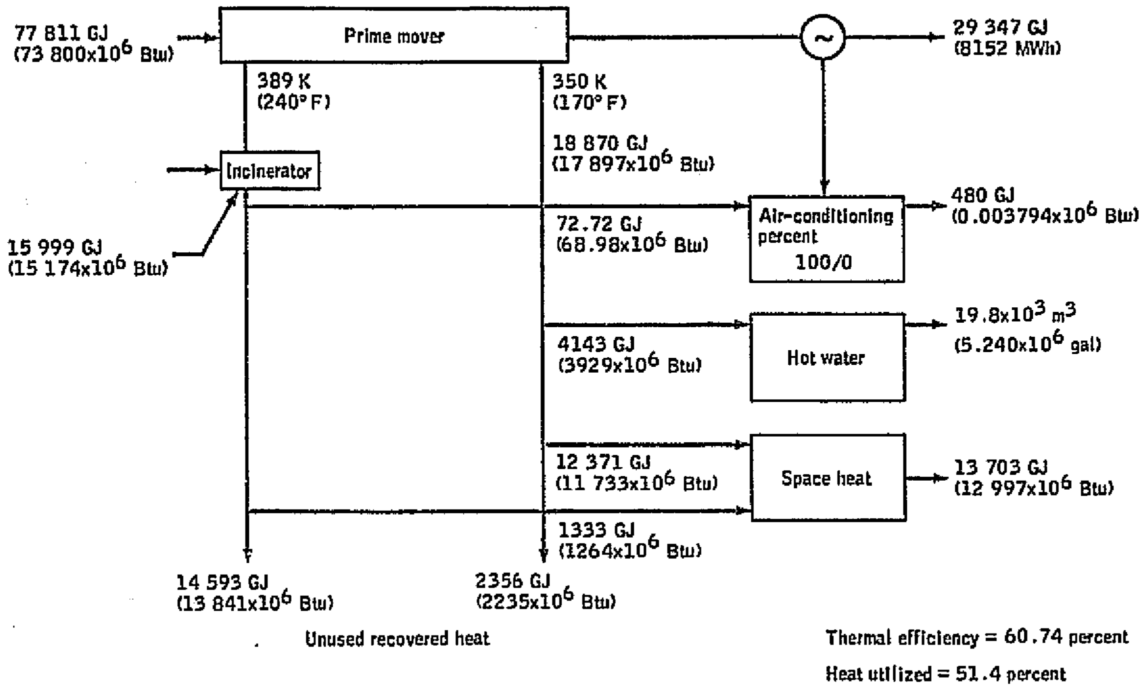
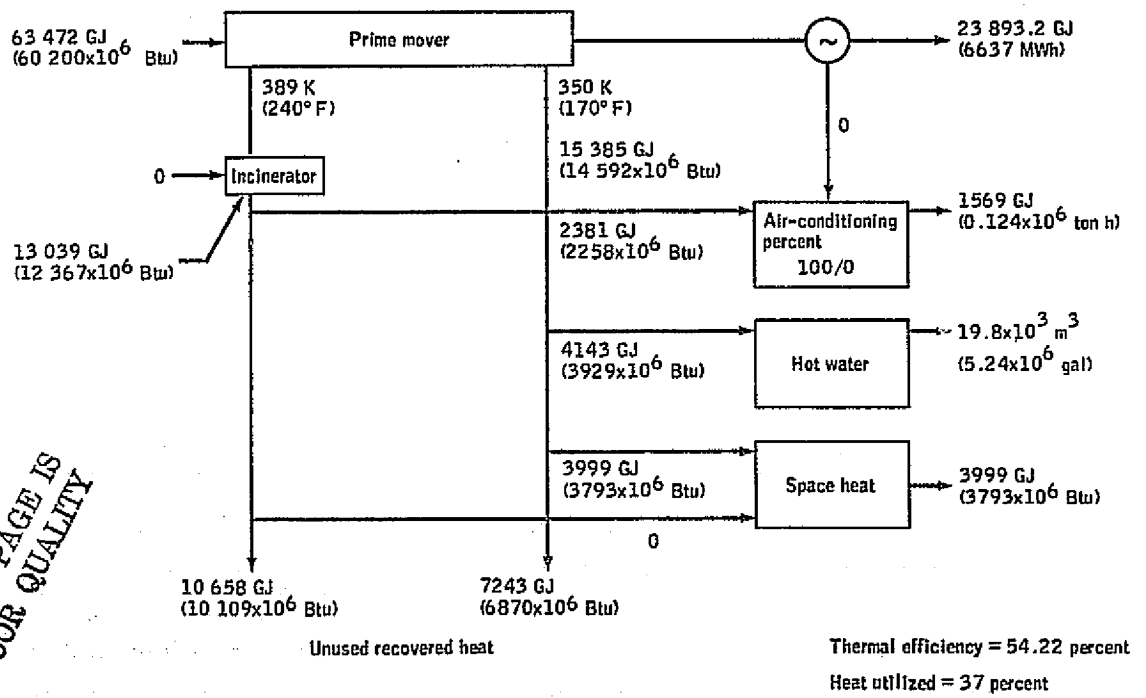


Figure C-4.- Bar chart showing neighborhood MIUS annual energy utilization.

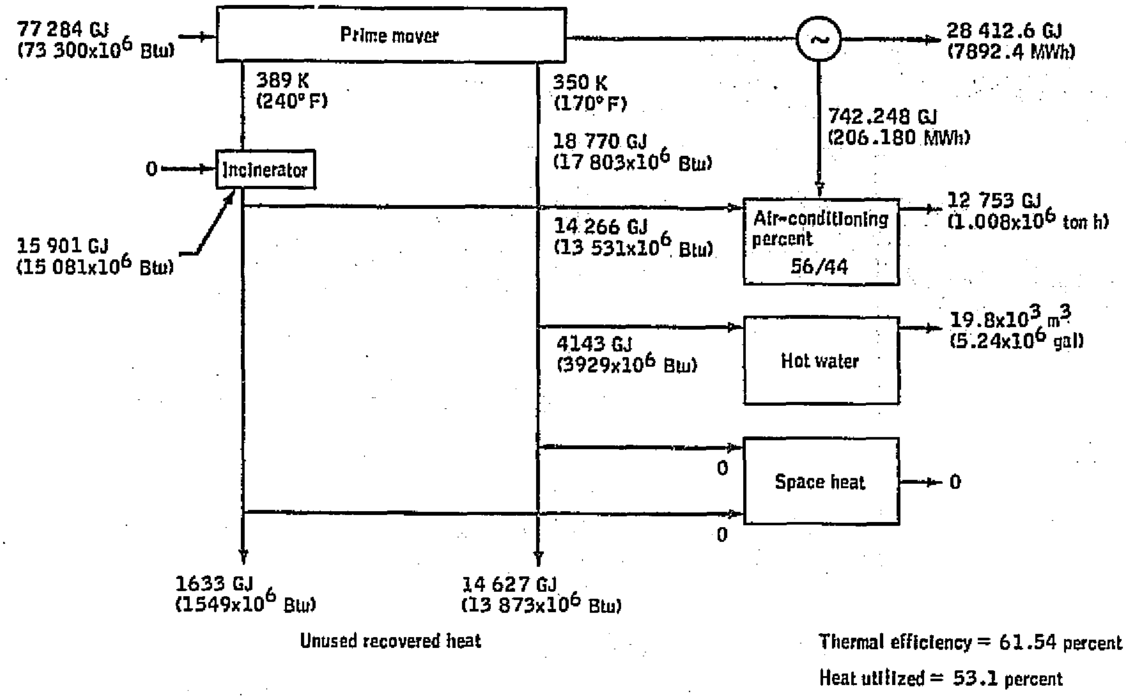


(a) Winter.

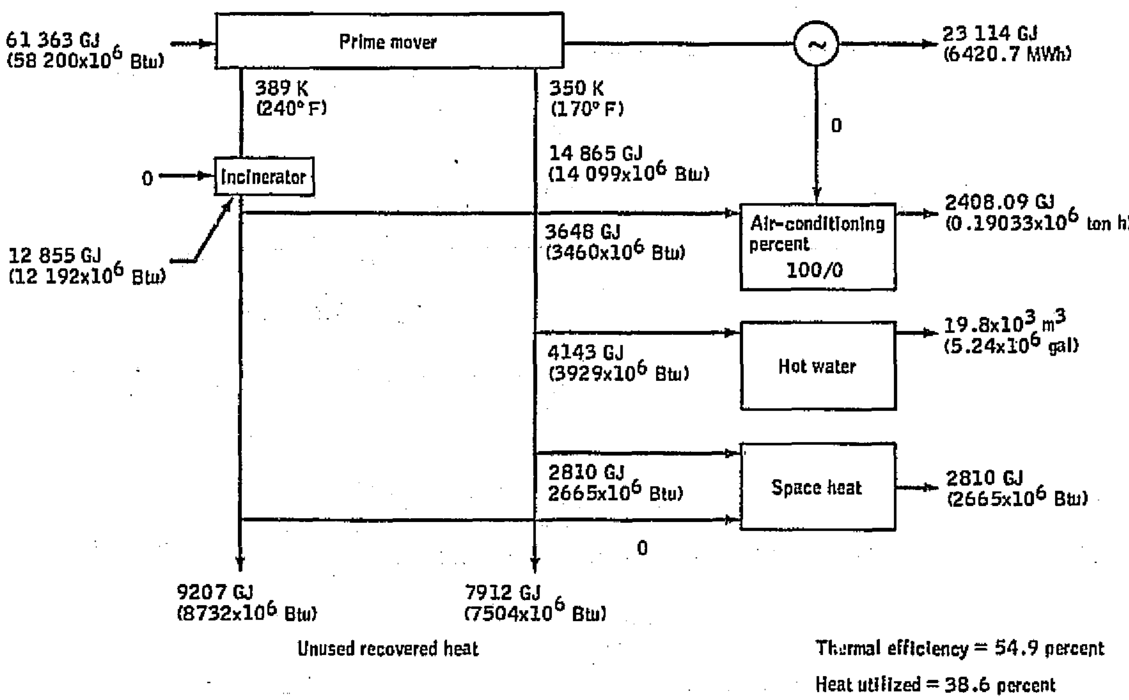


(b) Spring.

Figure C-5.- Neighborhood MIUS energy utilization.

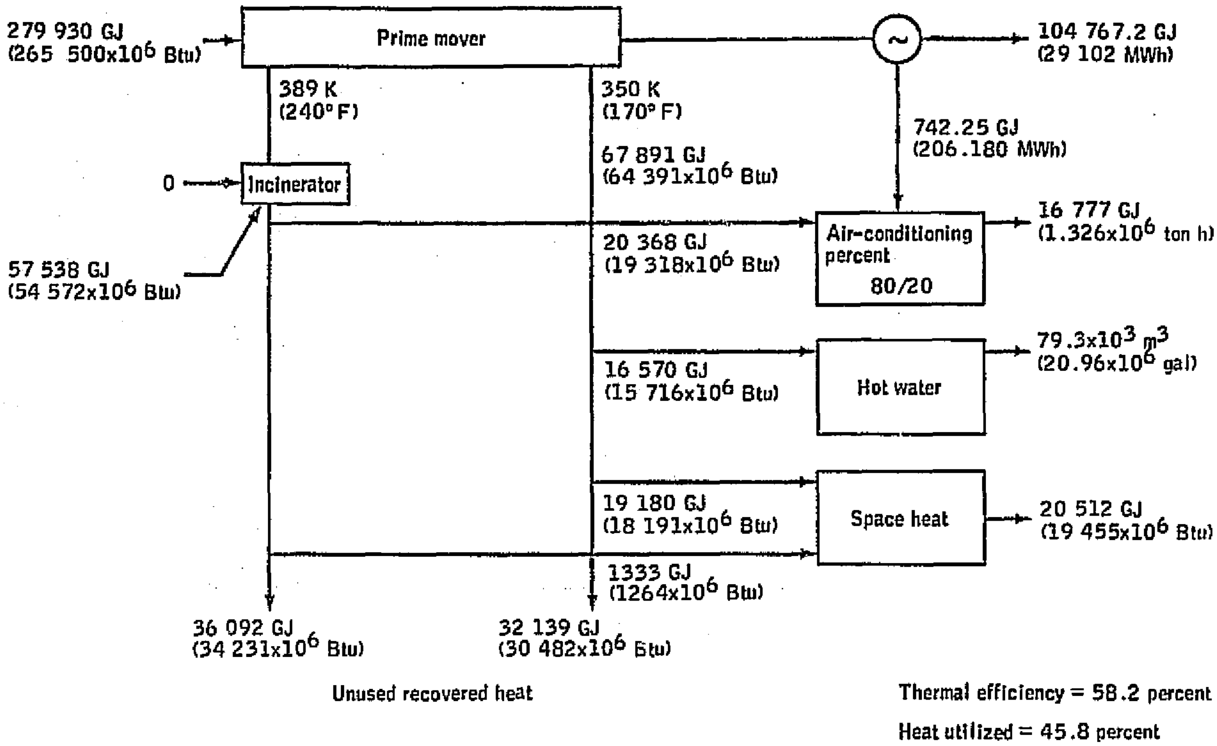


(c) Summer.



(d) Fall.

Figure C-5.- Continued.



(e) Annual season.

Figure C-5.- Concluded.

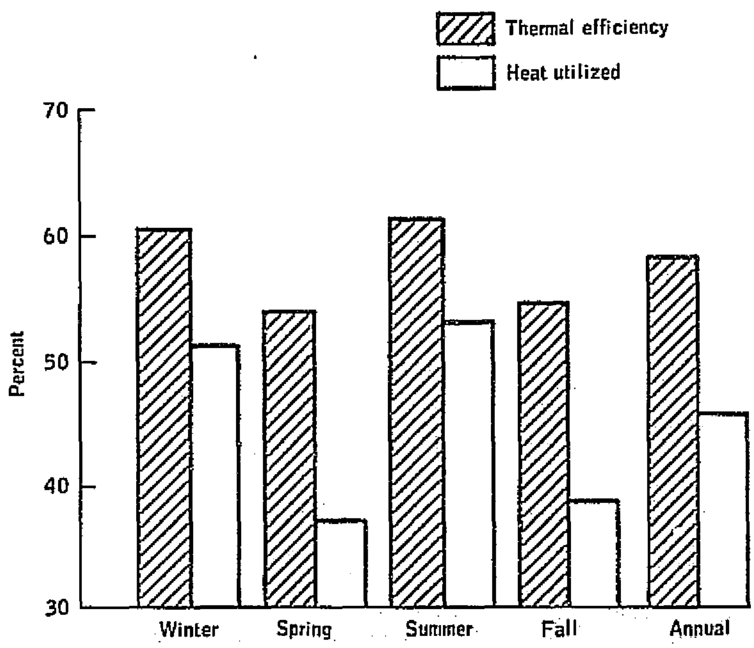
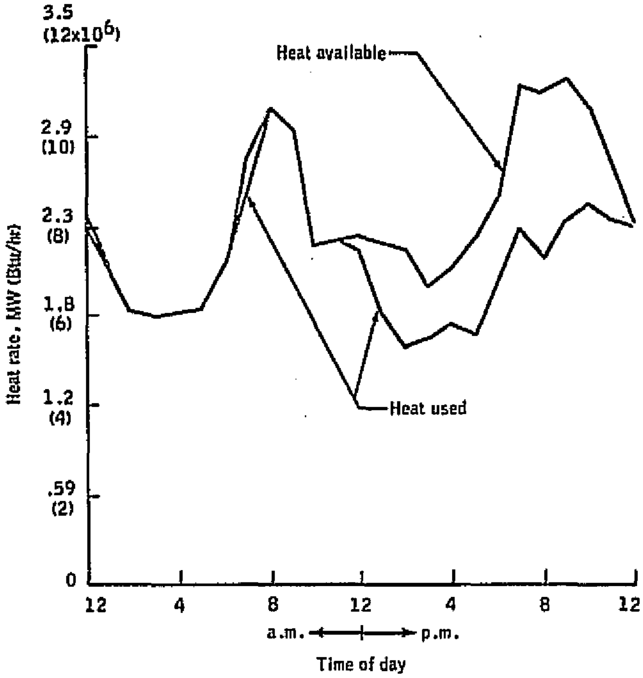
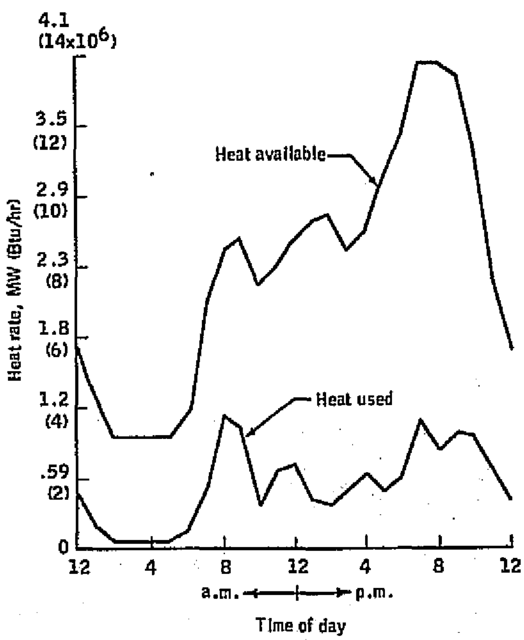


Figure C-6.- Neighborhood MIUS thermal efficiency.

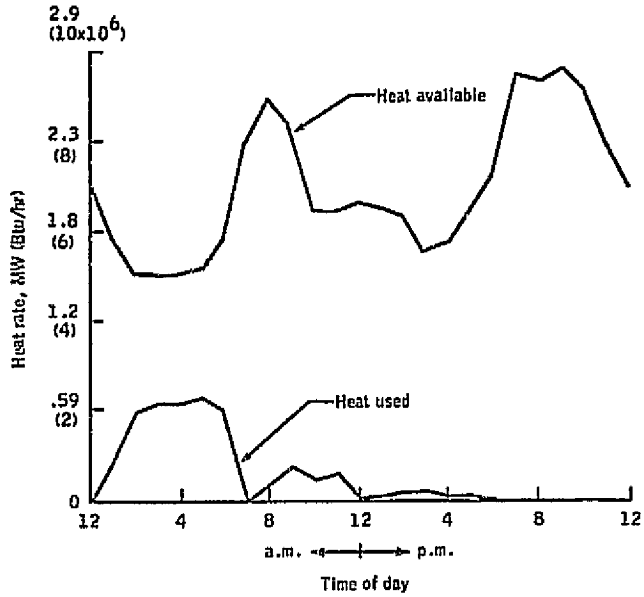


(a) Winter.

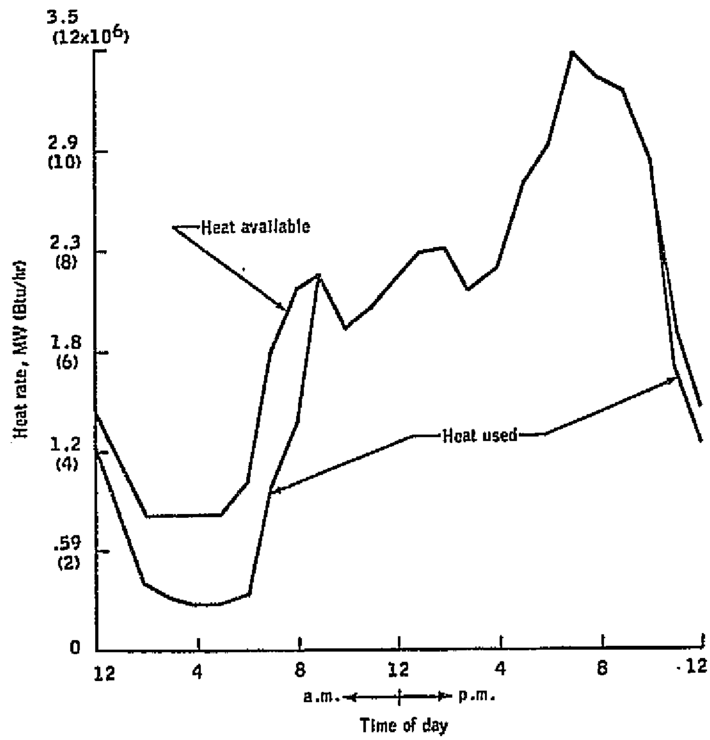


(b) Summer.

Figure C-7.- Neighborhood MIUS low-grade heat availability and utilization (based on average weather and floating air-conditioning).

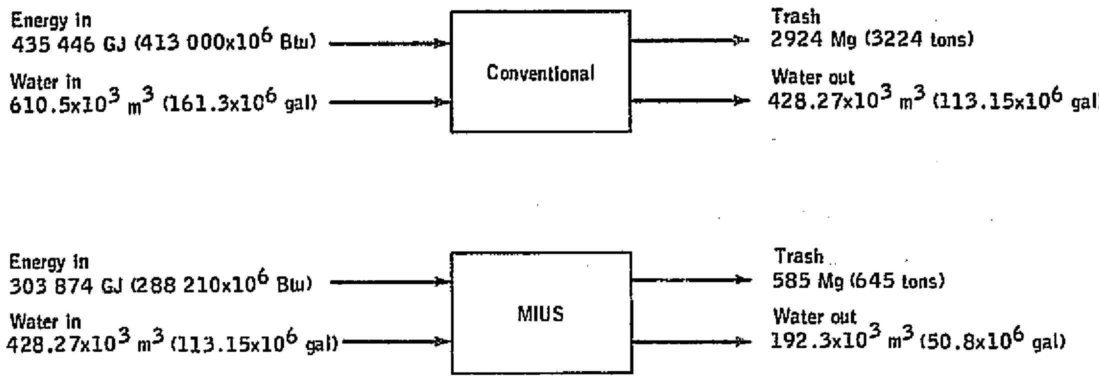


(a) Winter.



(b) Summer.

Figure C-8.- Neighborhood MIUS high-grade heat availability and utilization (based on average weather and floating air-conditioning).



Category	Savings, percent
Water savings	29.9
Effluent reduction	55.1
Trash load reduction	80.0
Energy savings	
Winter	34.4
Spring	28.2
Summer	29.7
Fall	27.9
Annual	30.2

Figure C-9.- Comparison of annual figures for a village center MIUS and a conventional system.

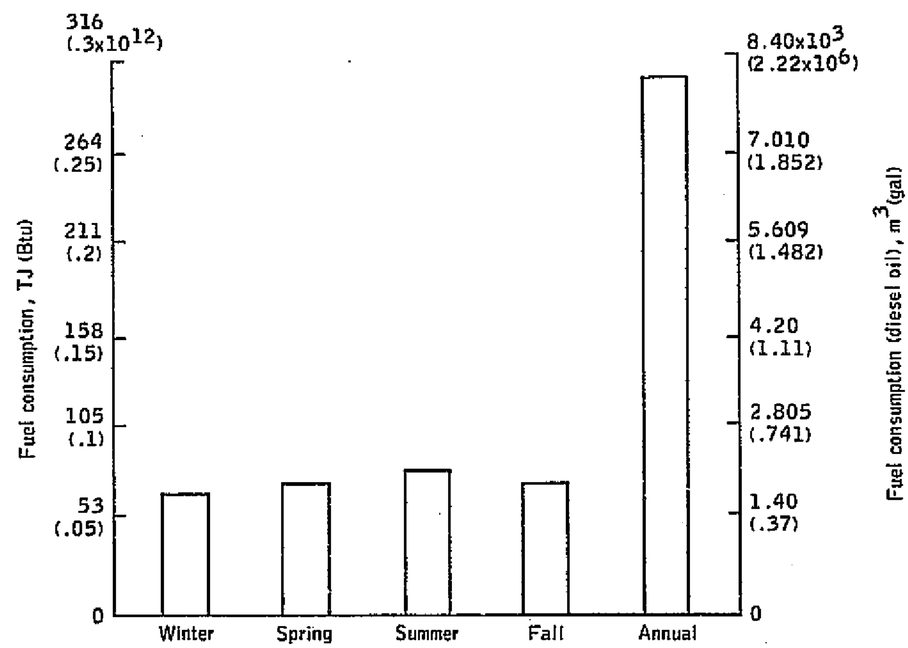


Figure C-10.- Village center MIUS fuel consumption.

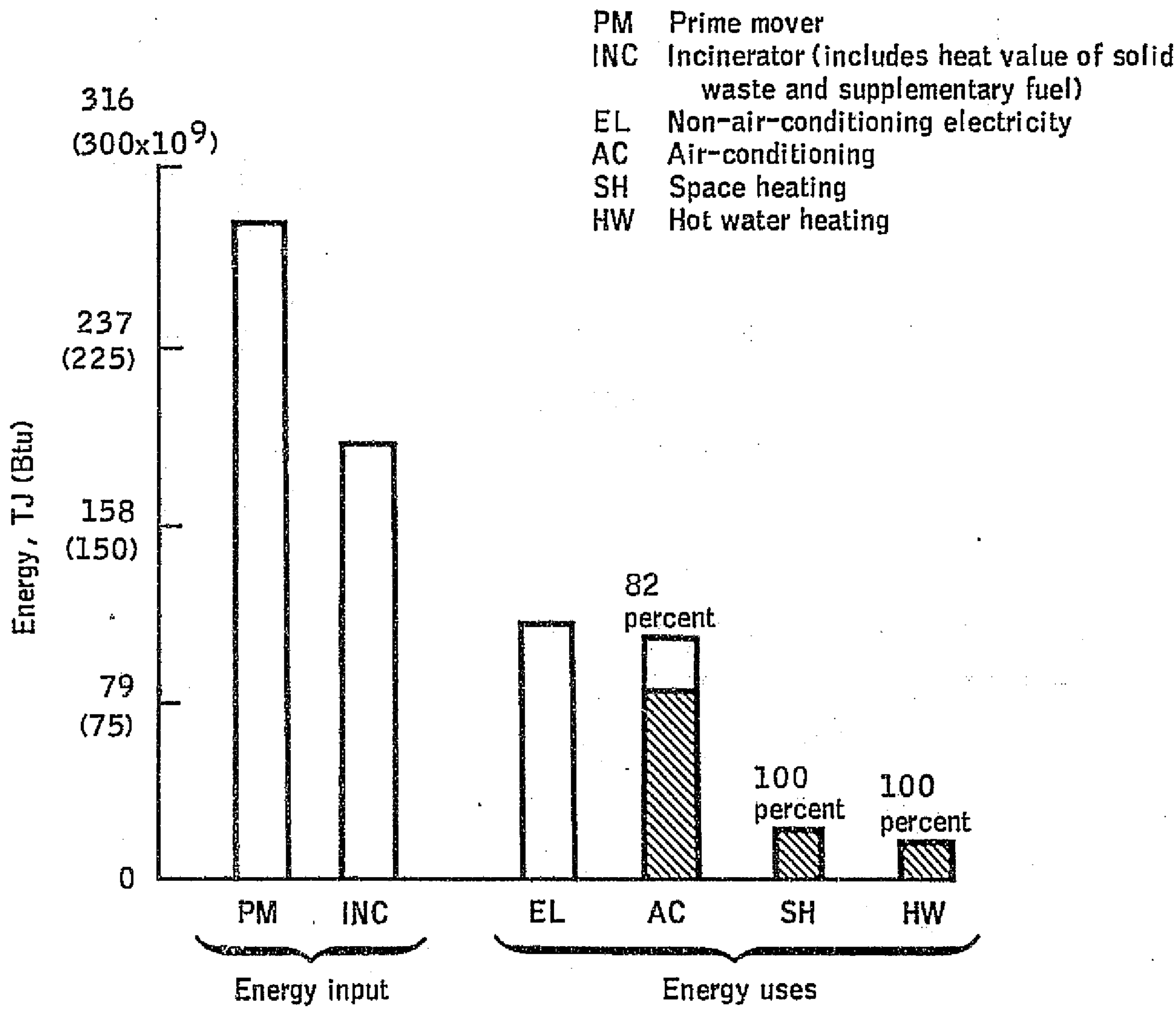
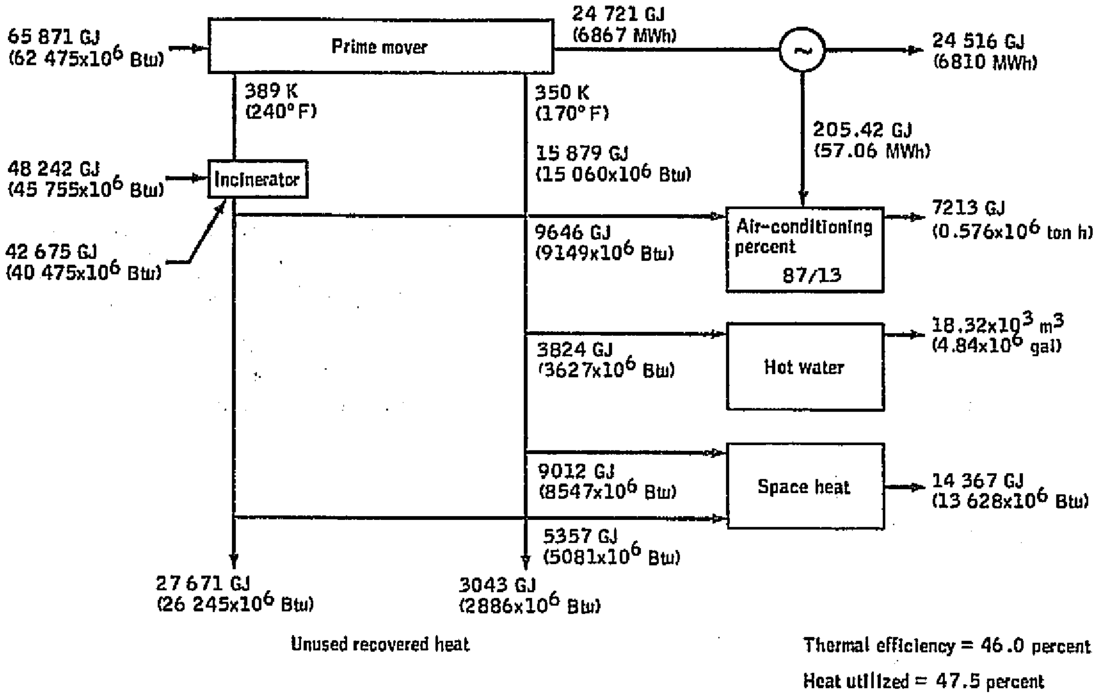
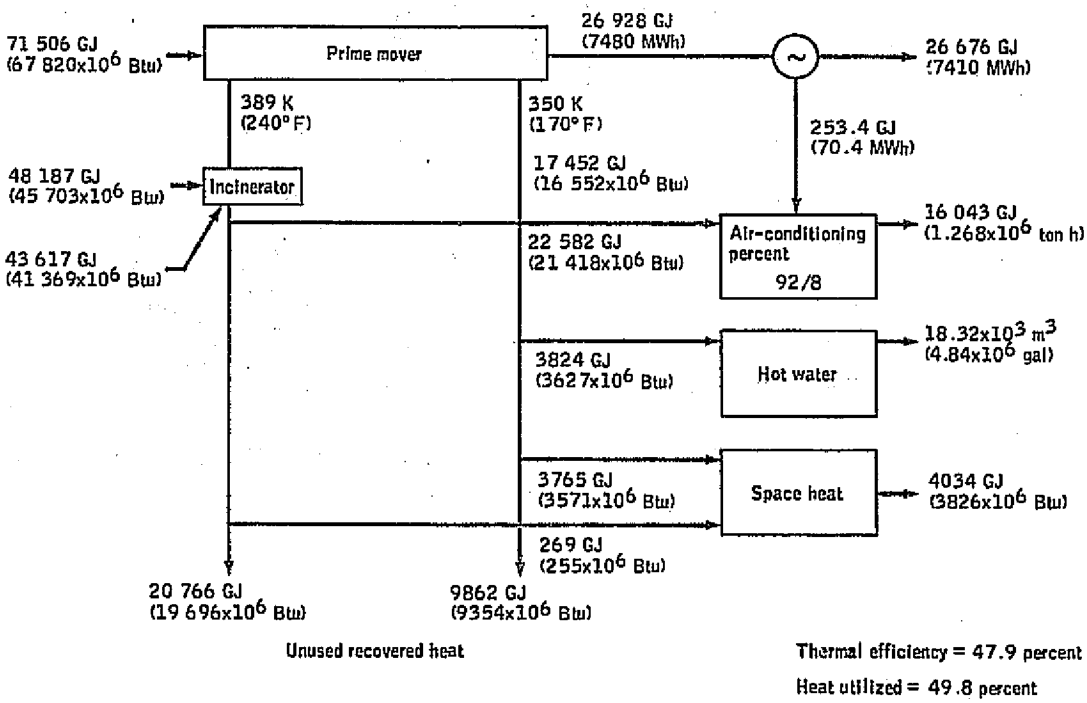


Figure C-11.- Bar chart showing village center MIUS annual energy utilization.

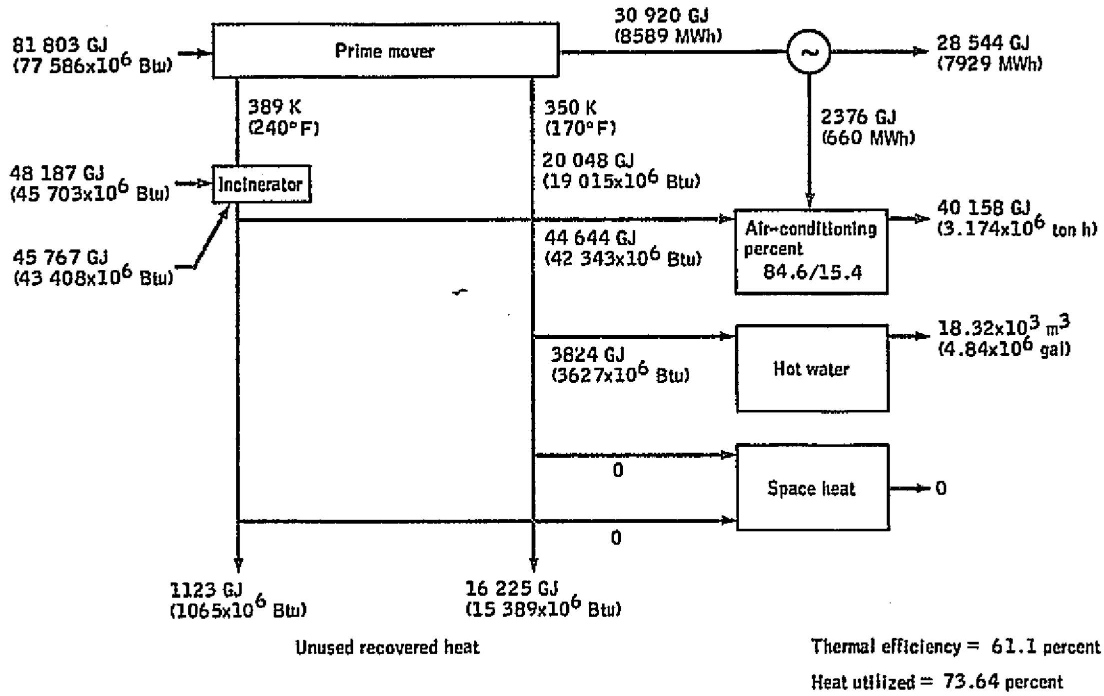


(a) Winter.

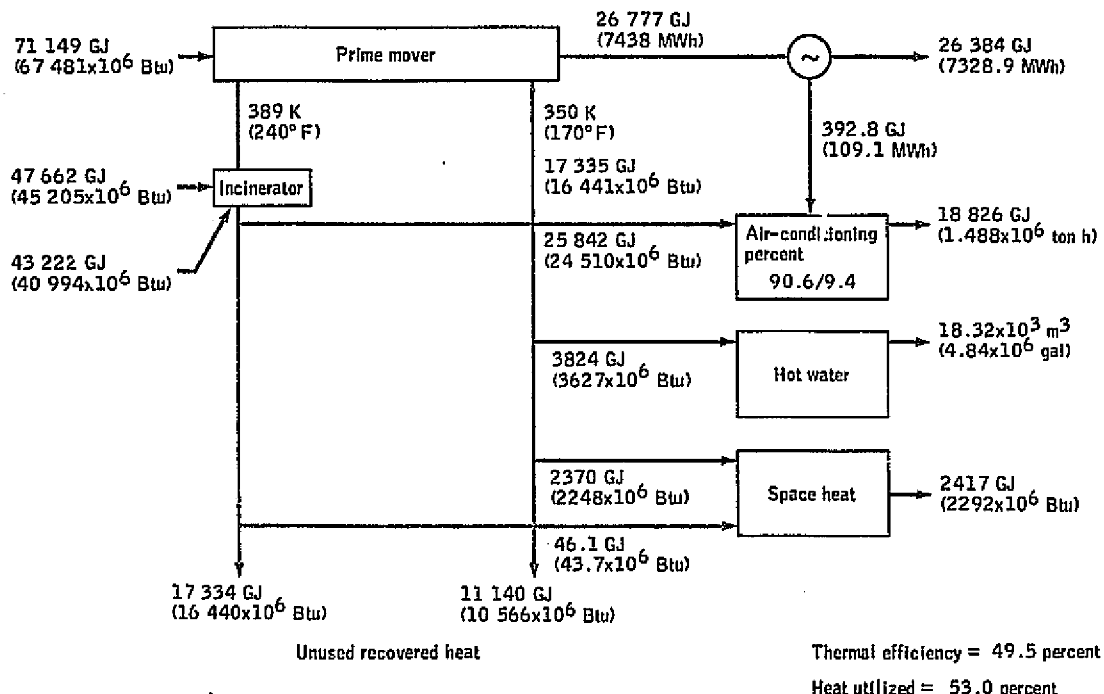


(b) Spring.

Figure C-12.- Village center MIUS energy utilization.

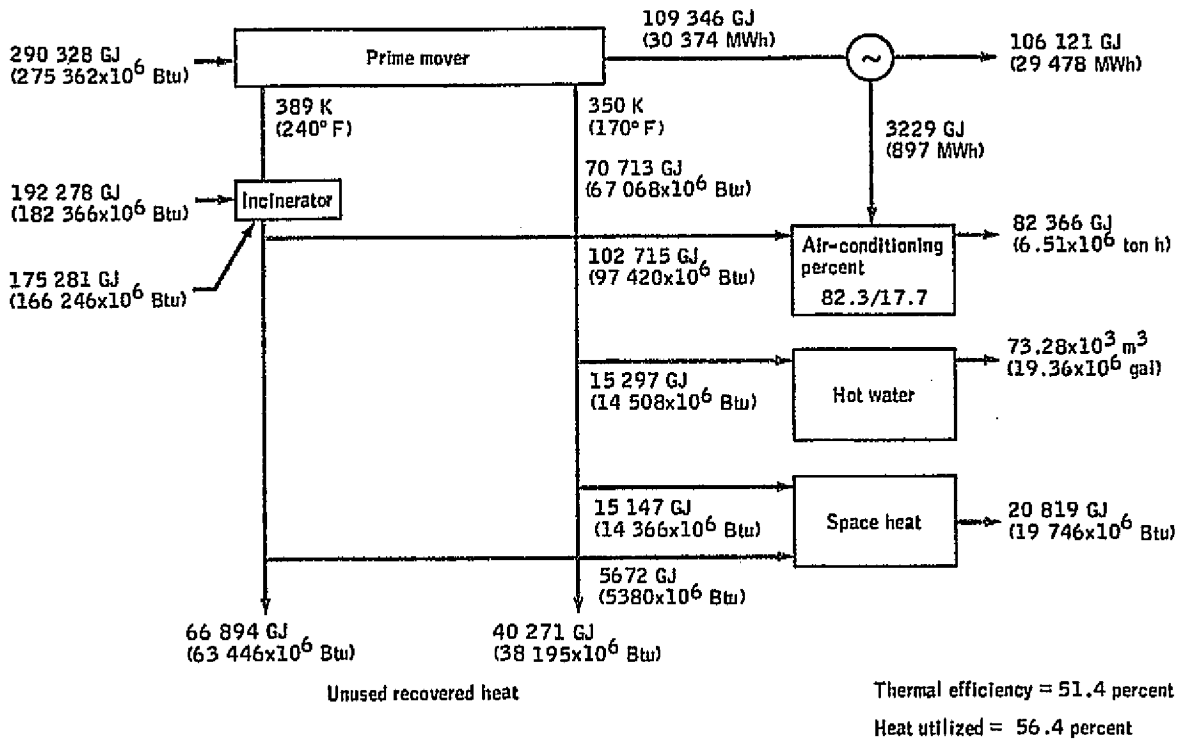


(c) Summer.



(d) Fall.

Figure C-12.- Continued.



(e) Annual season.

Figure C-12.- Concluded.

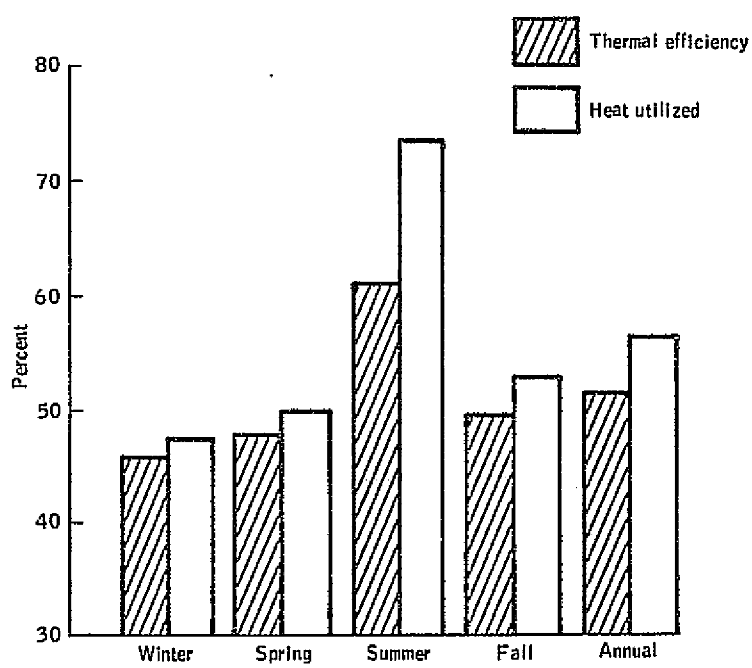
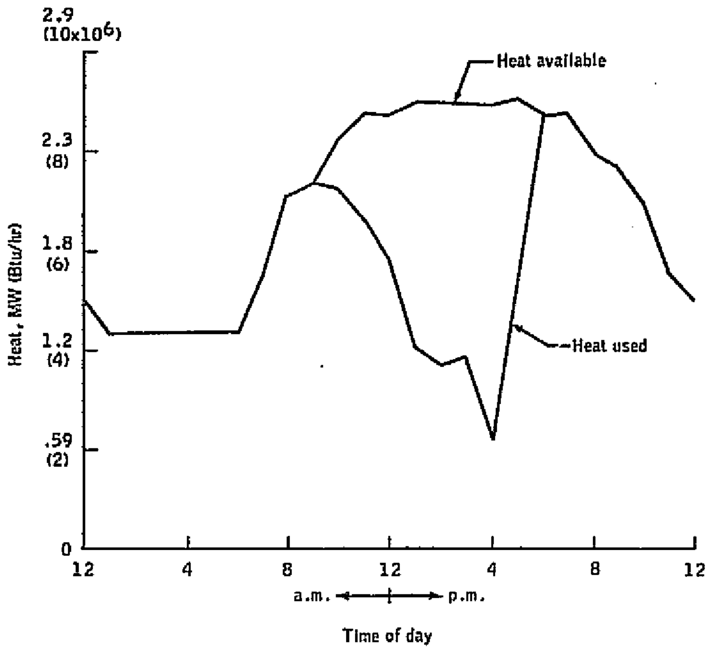
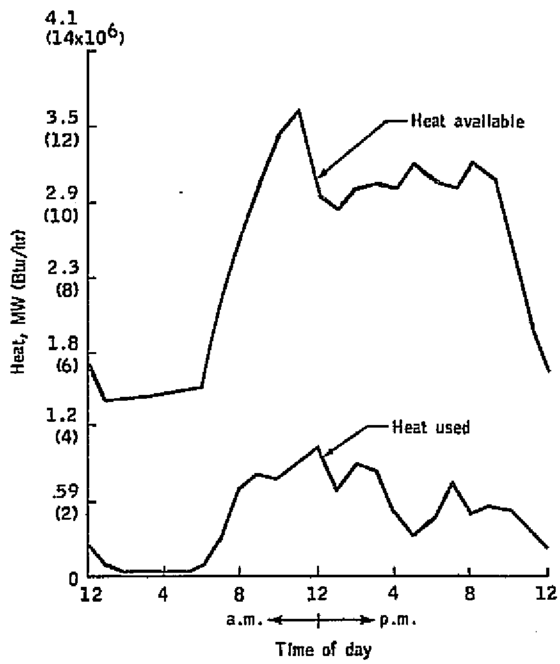


Figure C-13.- Village center MIUS thermal efficiency.

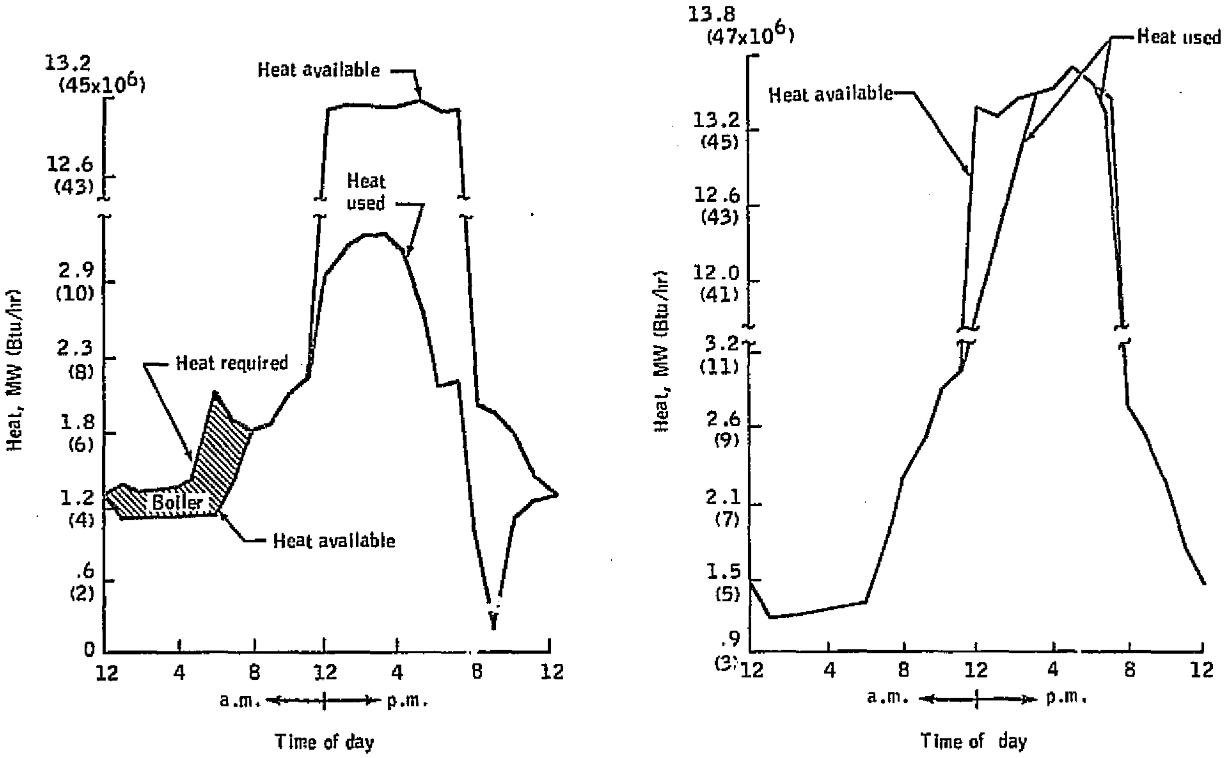


(a) Winter.



(b) Summer.

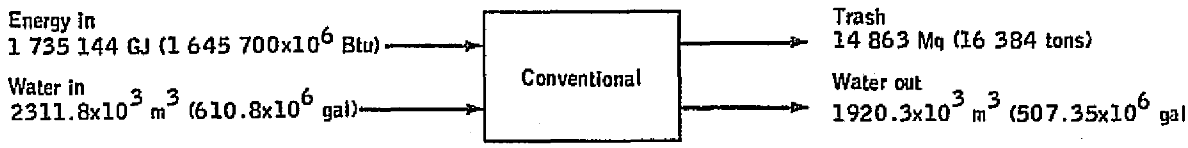
Figure C-14.- Village center MIUS low-grade availability and utilization (based on average weather and floating air-conditioning).



(a) Winter.

(b) Summer.

Figure C-15.- Village center MIUS high-grade heat availability and utilization (based on average weather and floating air-conditioning).



Category	Savings, percent
Water savings	16.9
Effluent reduction	25.1
Trash load reduction	80.0
Energy savings	
Winter	47.4
Spring	37.6
Summer	33.6
Fall	36.9
Annual	39.4

Figure C-16.- Comparison of annual figures for a village complex MIUS and a conventional system.

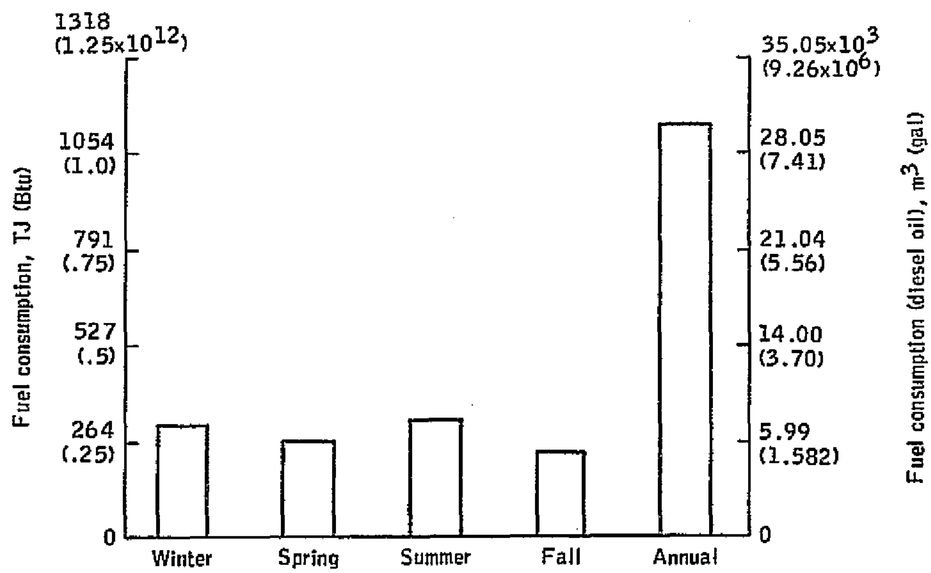


Figure C-17.- Village complex MIUS fuel consumption.

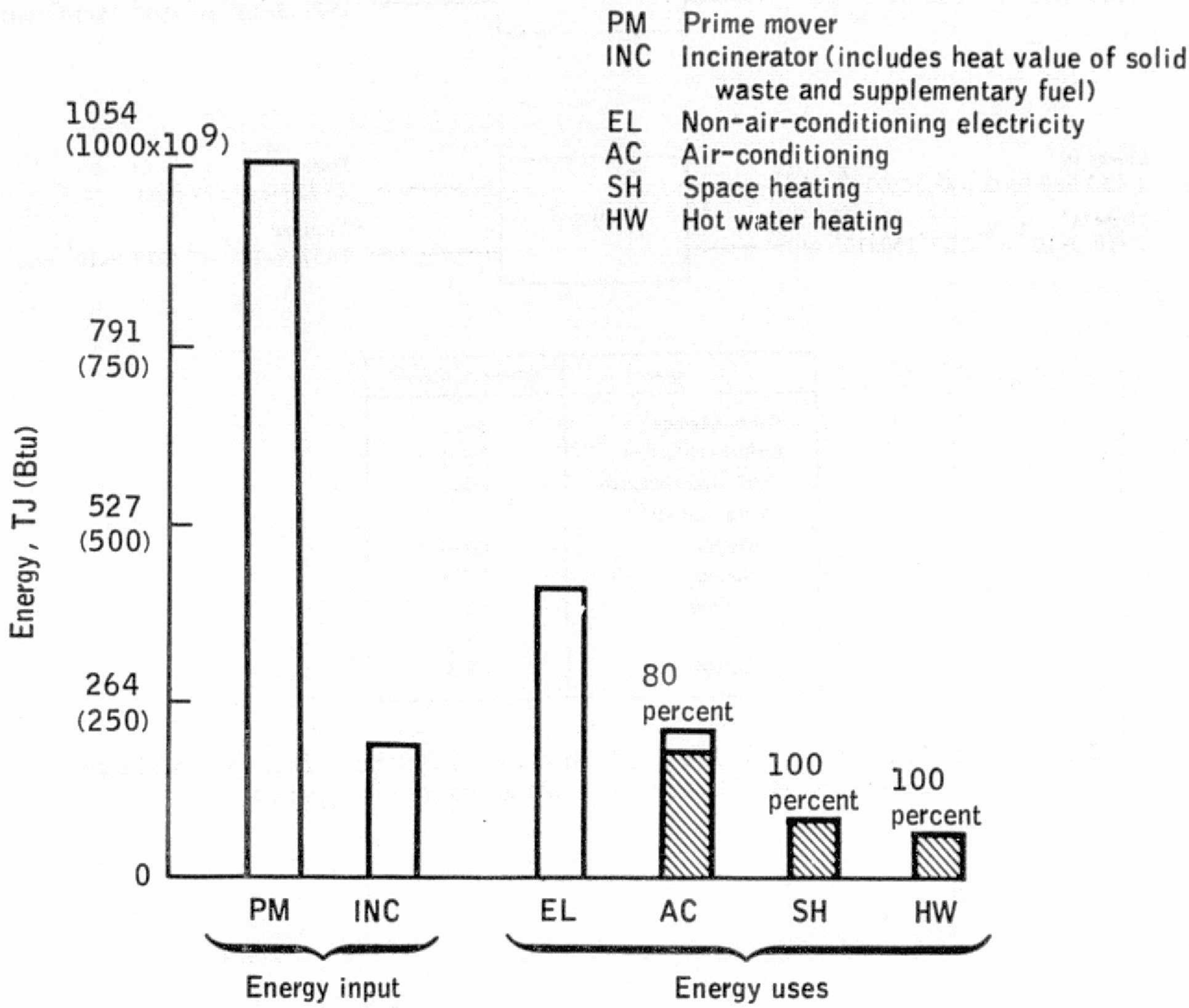
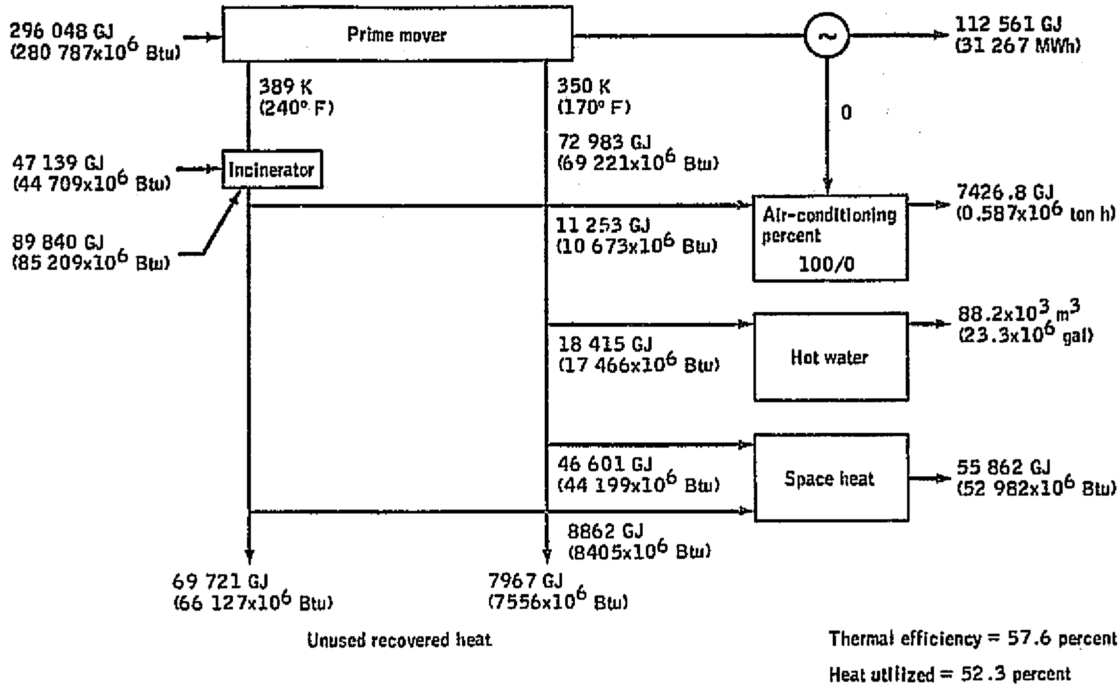
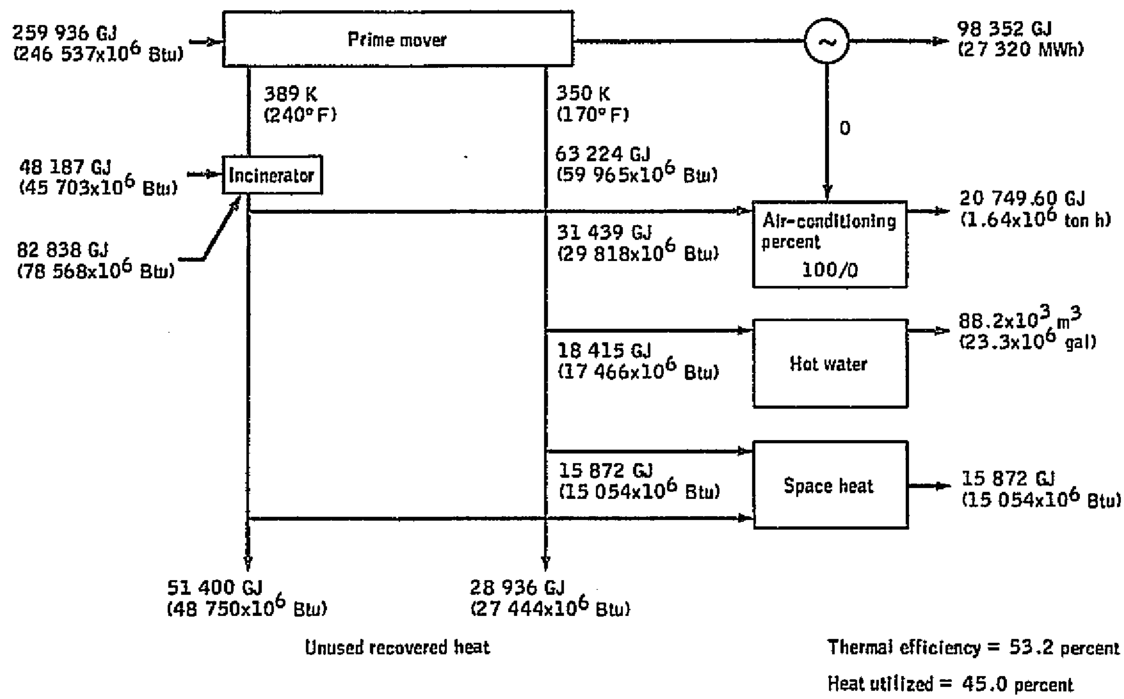


Figure C-18.- Bar chart showing village complex MIUS annual energy utilization.



(a) Winter.



(b) Spring.

Figure C-19.- Village complex MIUS energy utilization.

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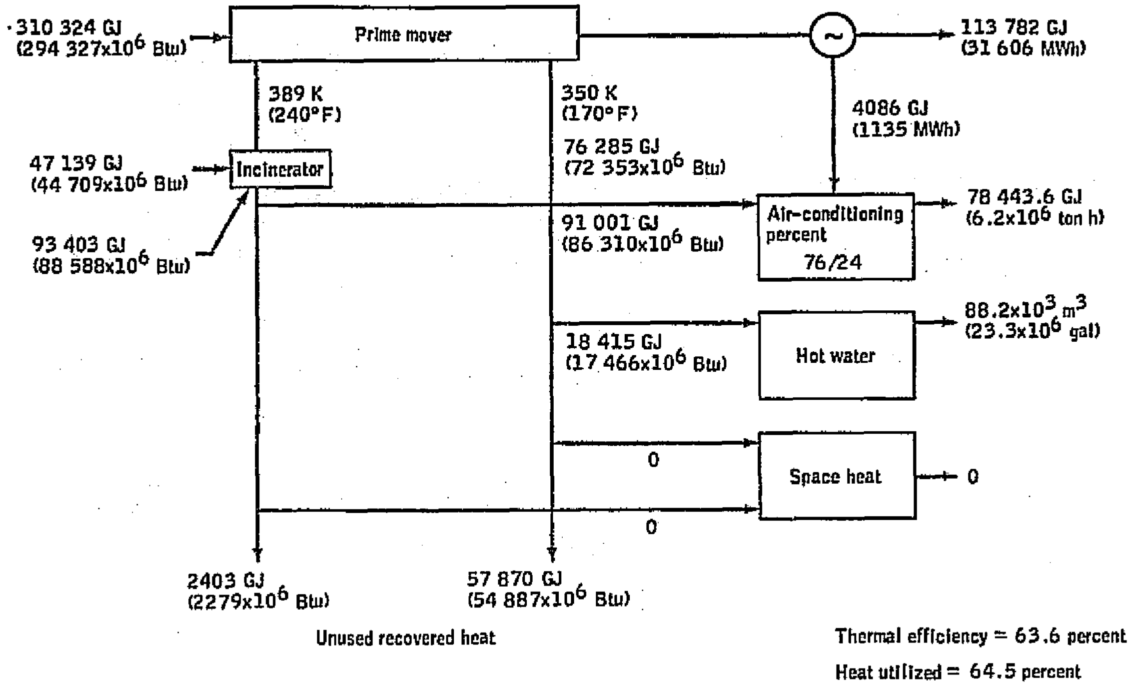
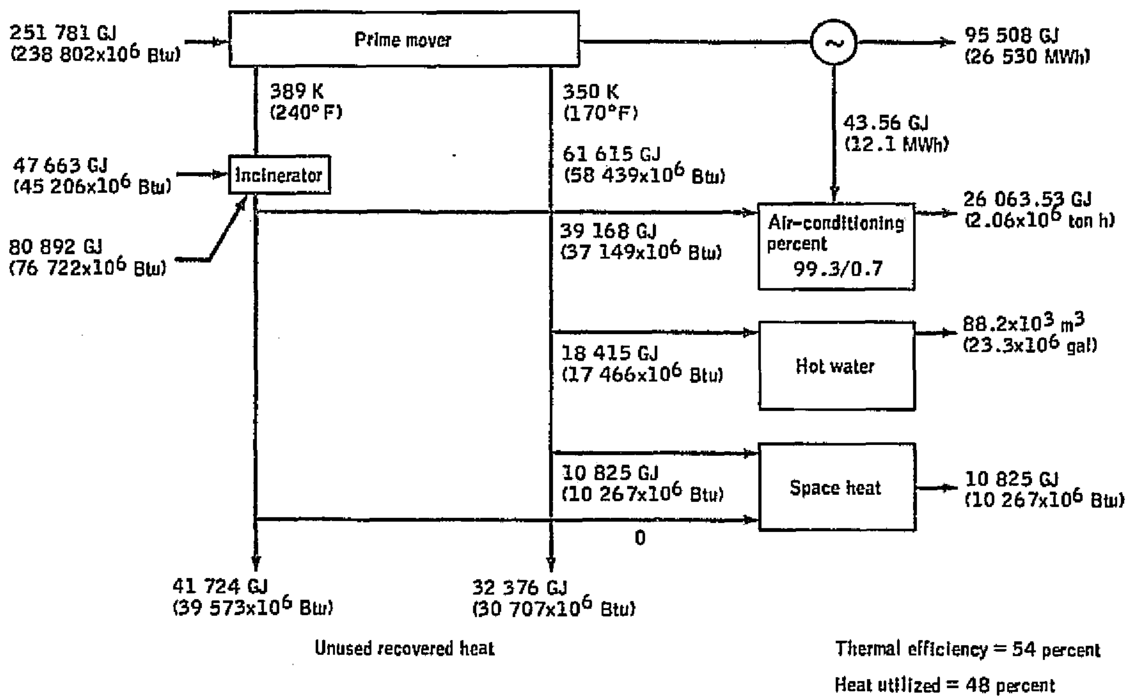
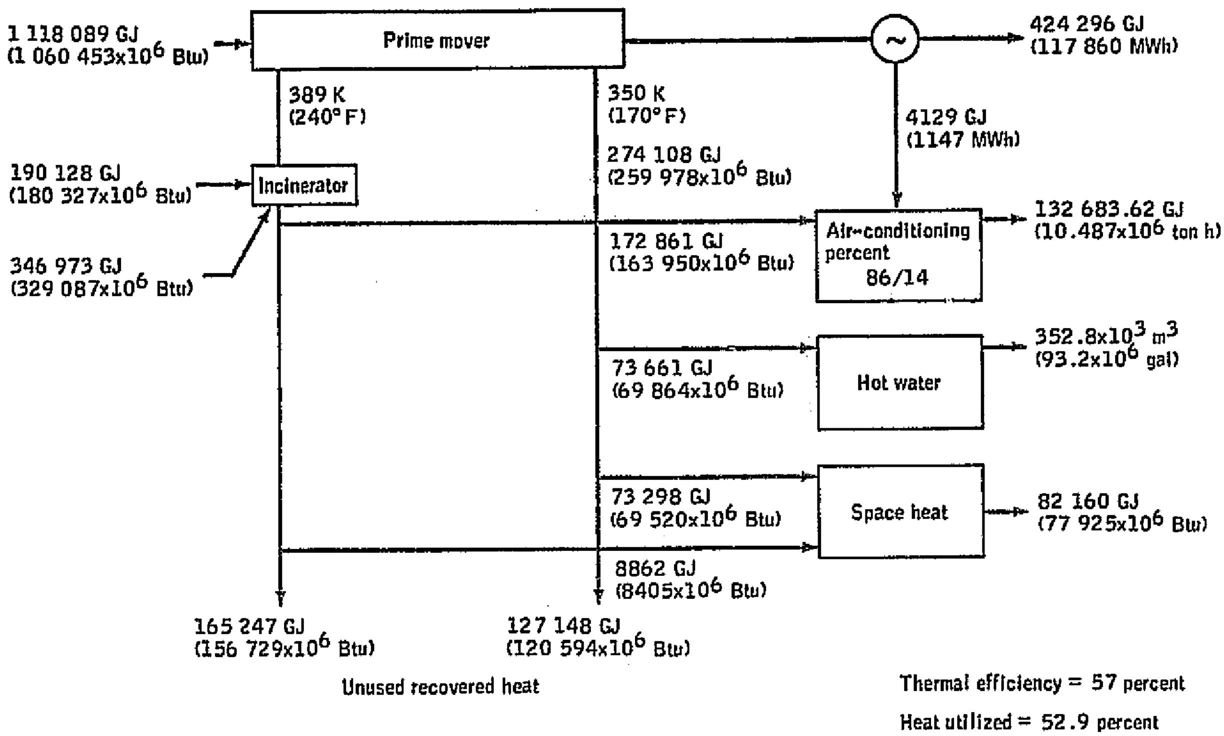


(c) Summer.



(d) Fall.

Figure C-19.- Continued.



(e) Annual season.

Figure C-19.- Concluded.

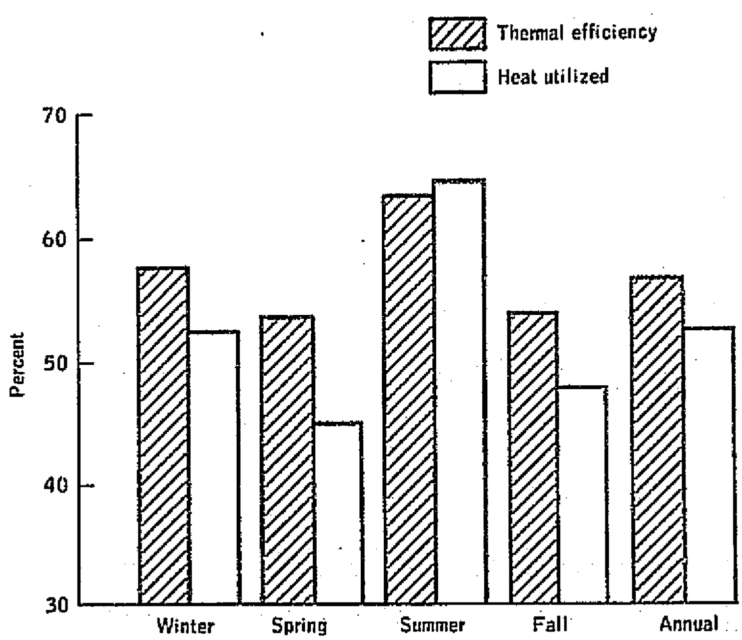
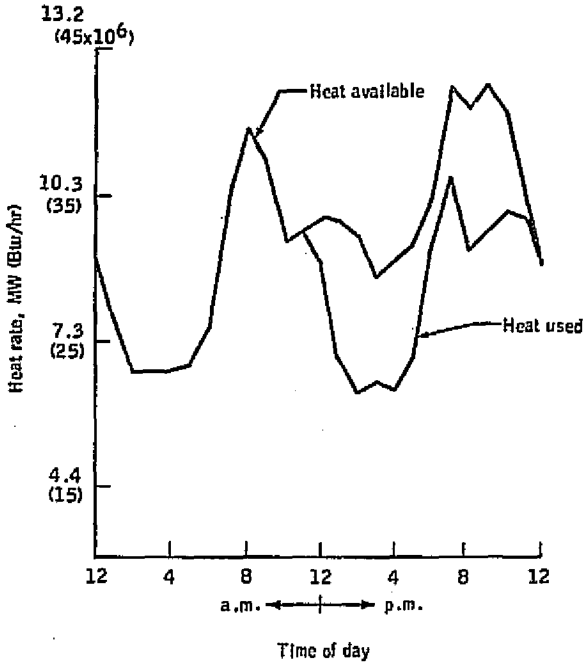
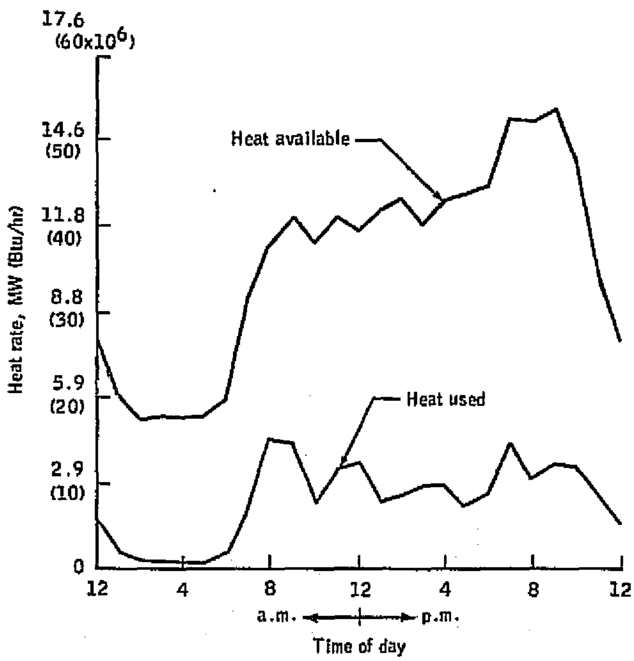


Figure C-20.- Village complex MIUS thermal efficiency.

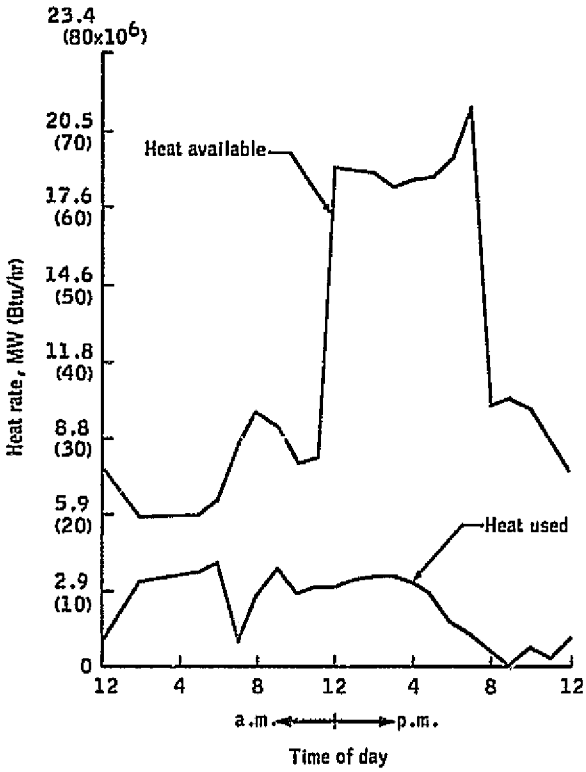


(a) Winter.

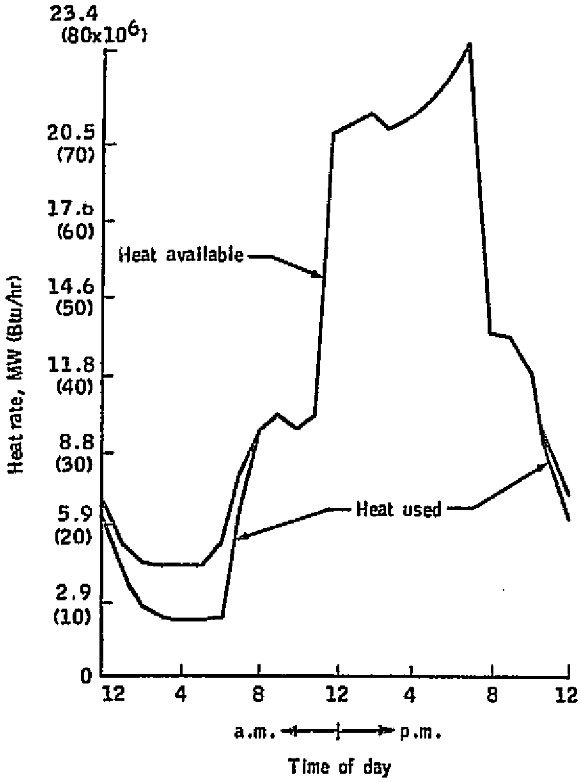


(b) Summer.

Figure C-21.- Village complex MIUS high-grade heat availability and utilization (based on average weather and floating air-conditioning).

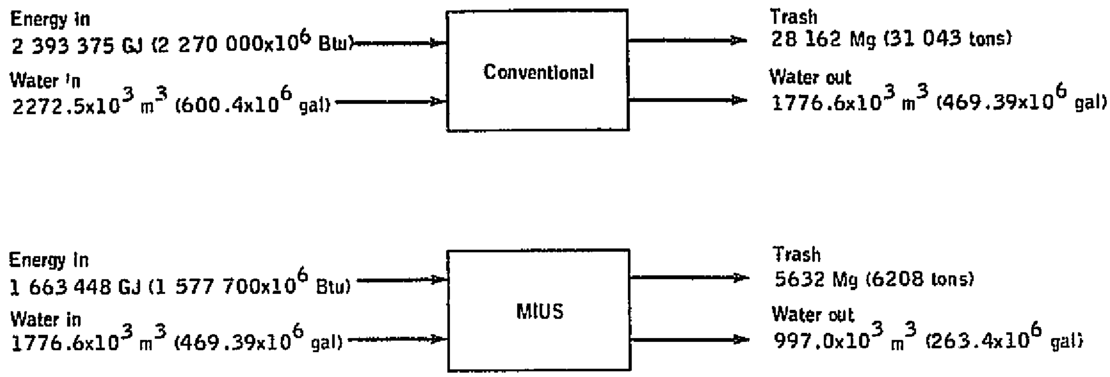


(a) Winter.



(b) Summer.

Figure C-22.- Village complex MIUS high-grade heat availability and utilization (based on average weather and floating air-conditioning).



Category	Savings, percent
Water savings	21.8
Effluent reduction	43.9
Trash load reduction	80.0
Energy savings	
Winter	33.5
Spring	30.6
Summer	28.0
Fall	30.5
Annual	30.5

Figure C-23.- Comparison of annual figures for a CBD MIUS and a conventional system.

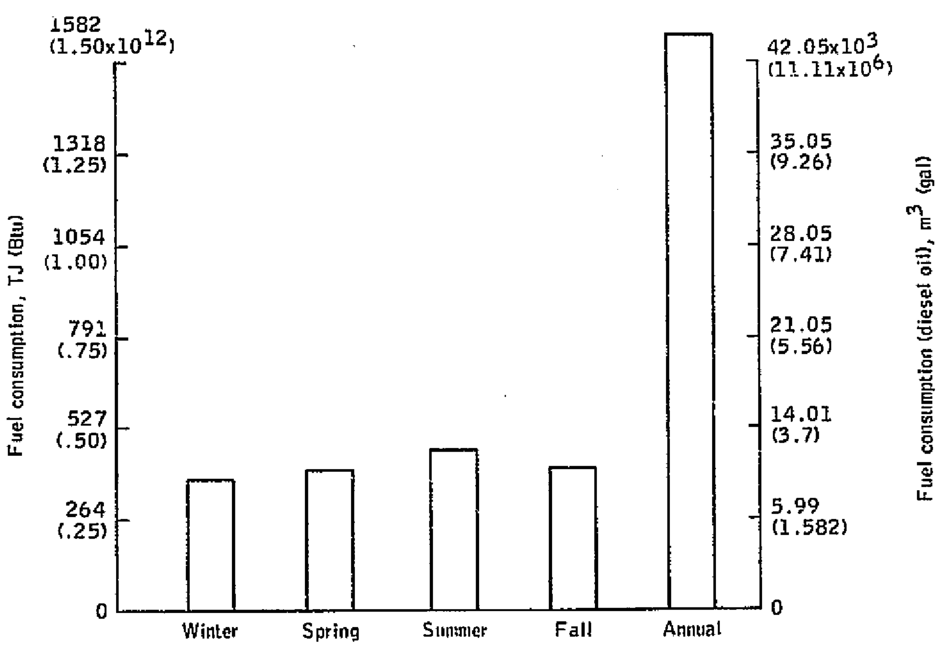


Figure C-24.- The CBD MIUS fuel consumption.

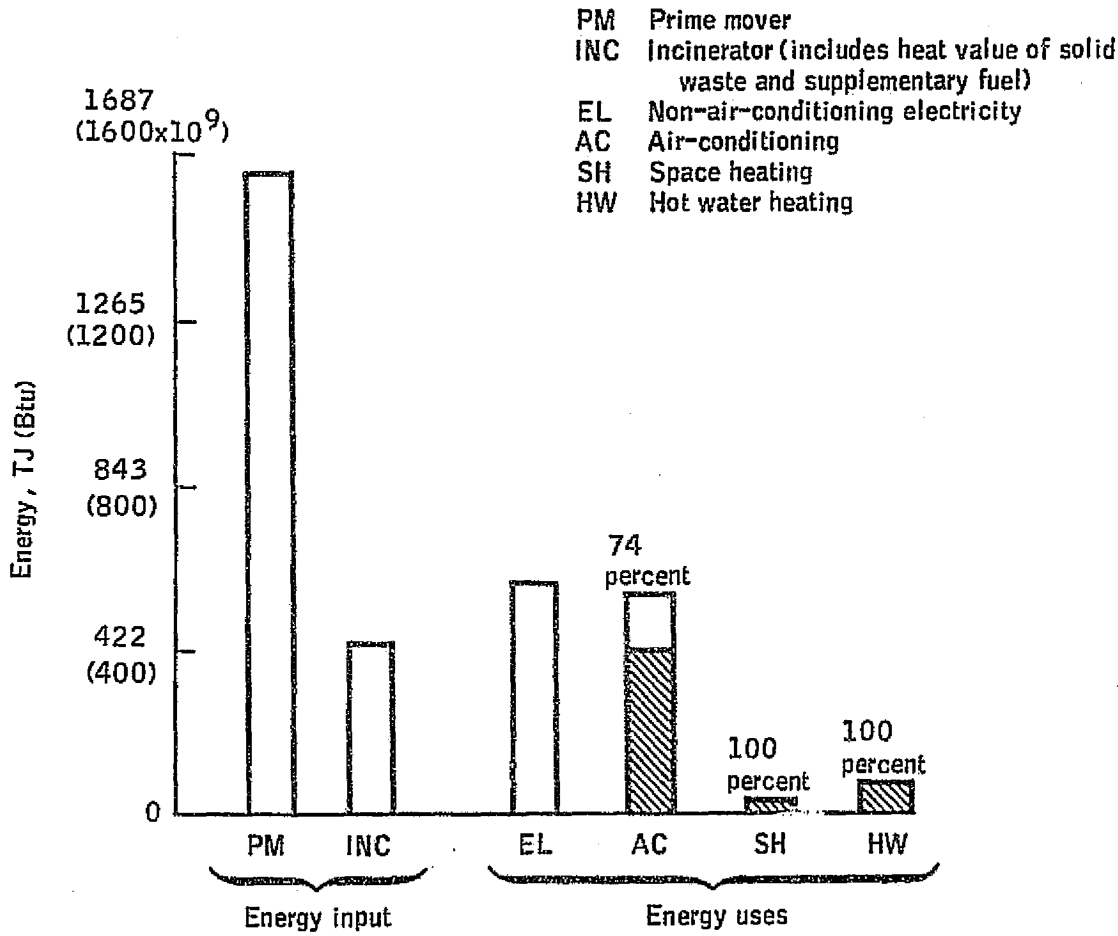
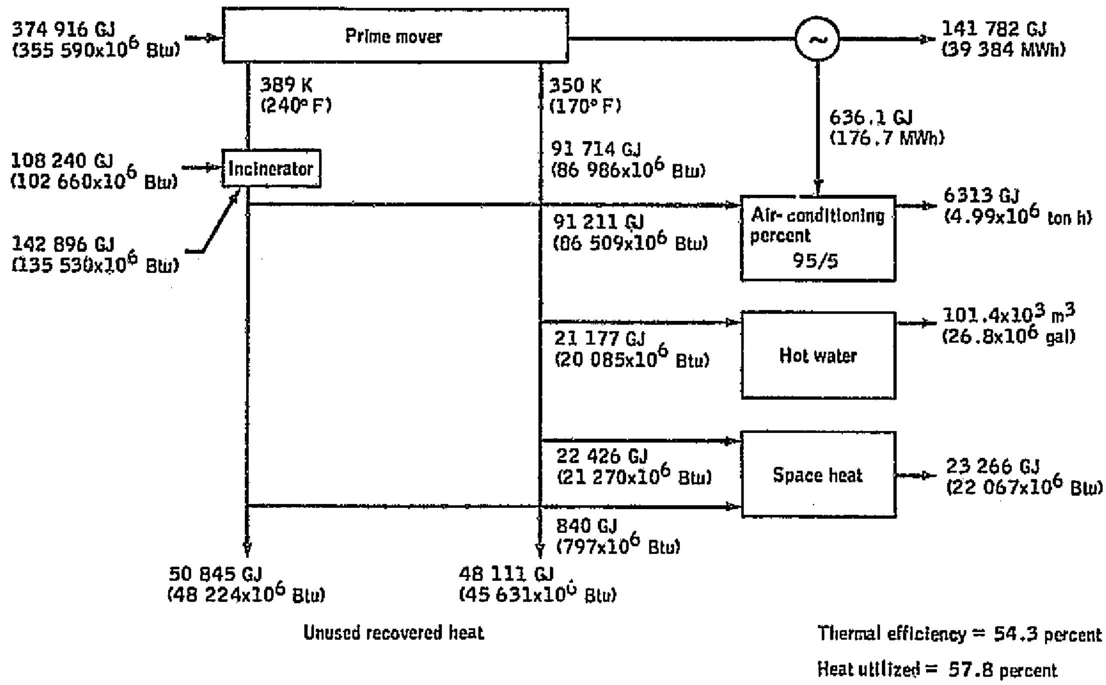
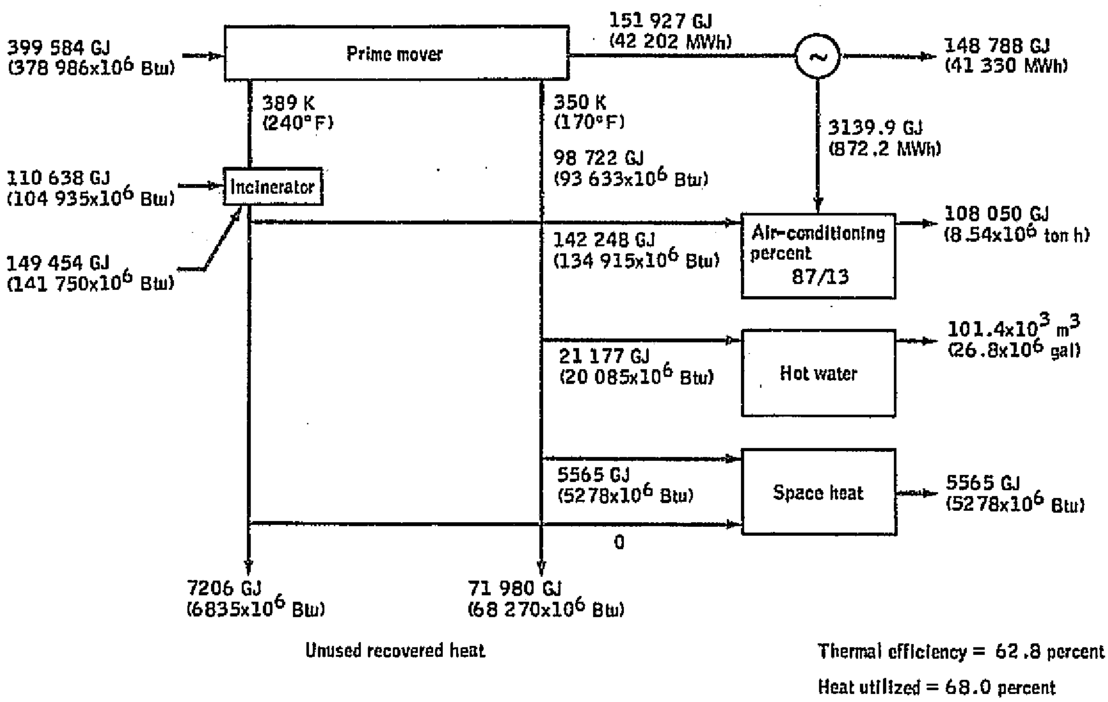


Figure C-25.- Bar chart showing CBD MIUS annual energy utilization.

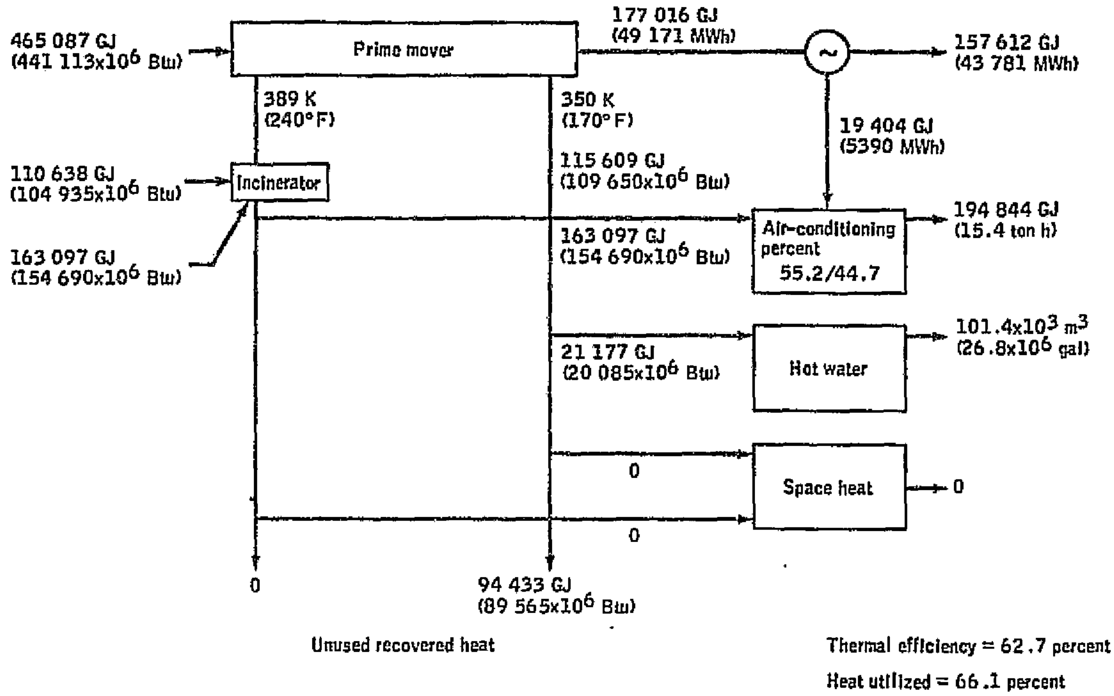


(a) Winter.

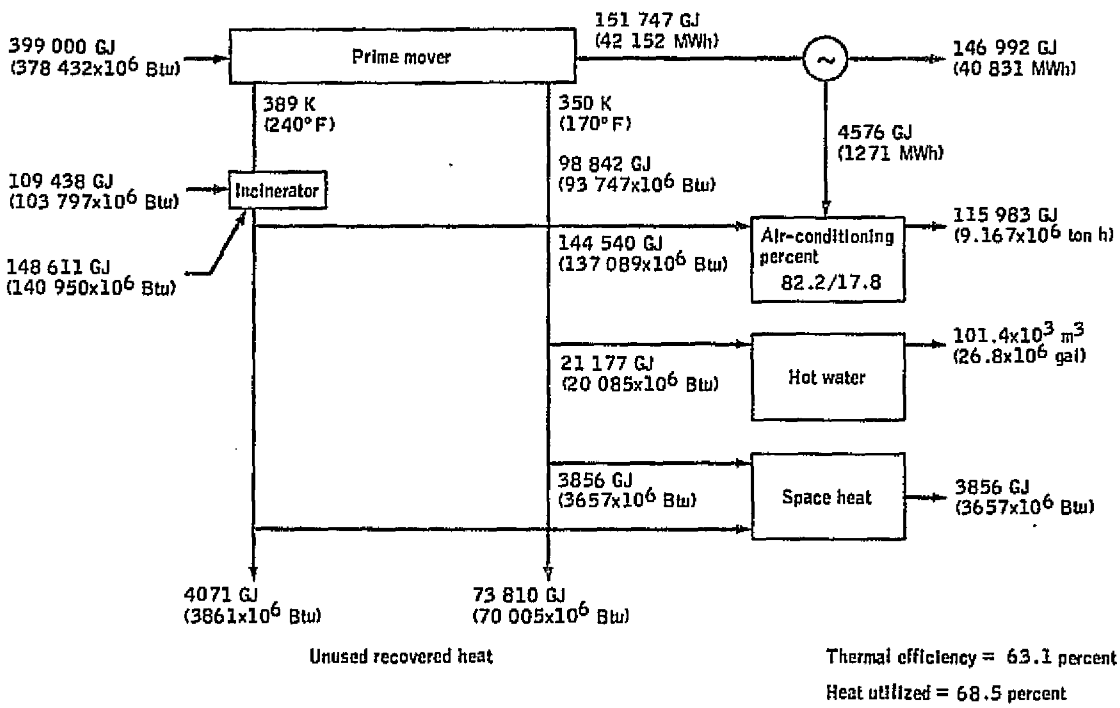


(b) Spring.

Figure C-26.- The CBD MIUS energy utilization.



(c) Summer.



(d) Fall.

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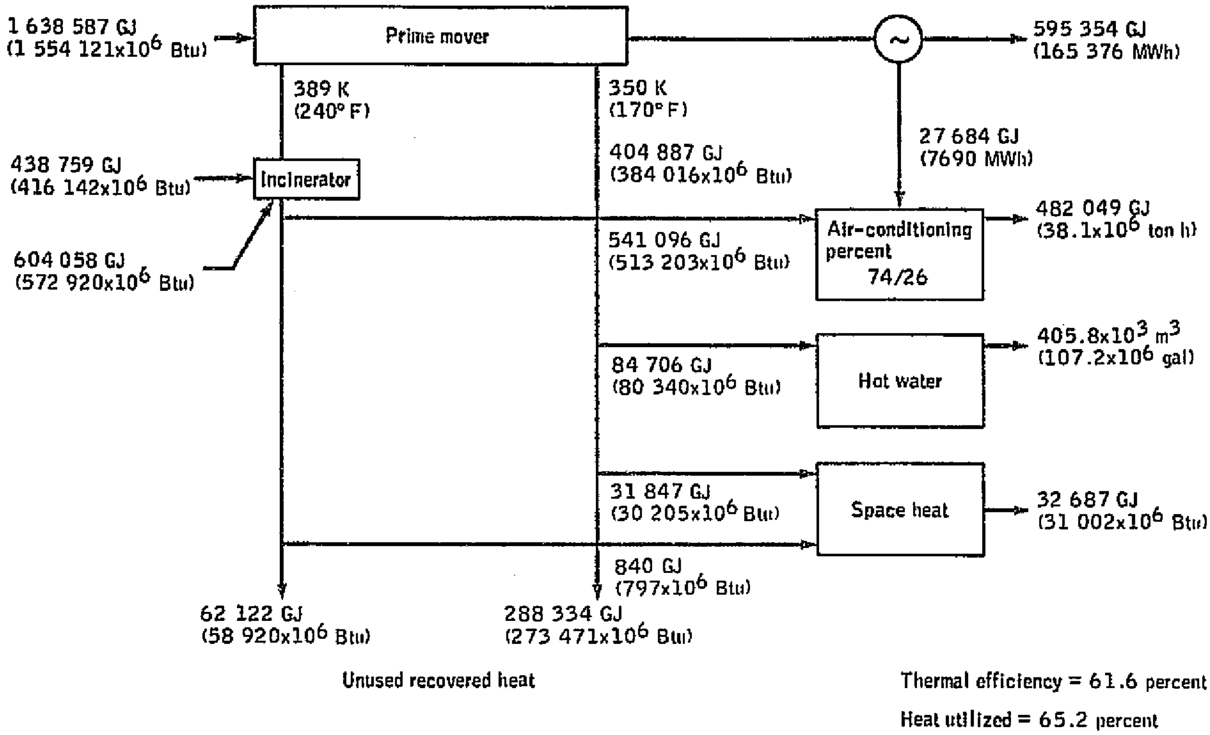
Figure C-26.- Continued.



(e) Annual season.

Figure C-26.- Concluded.

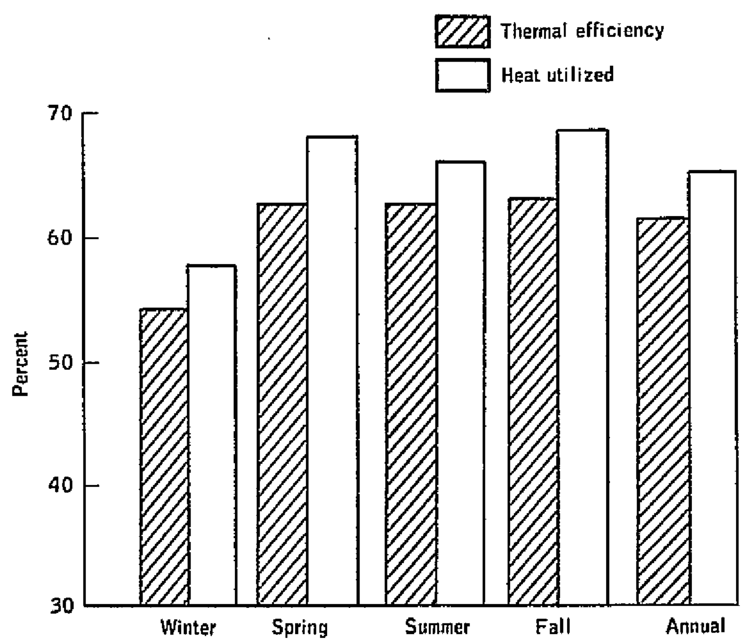
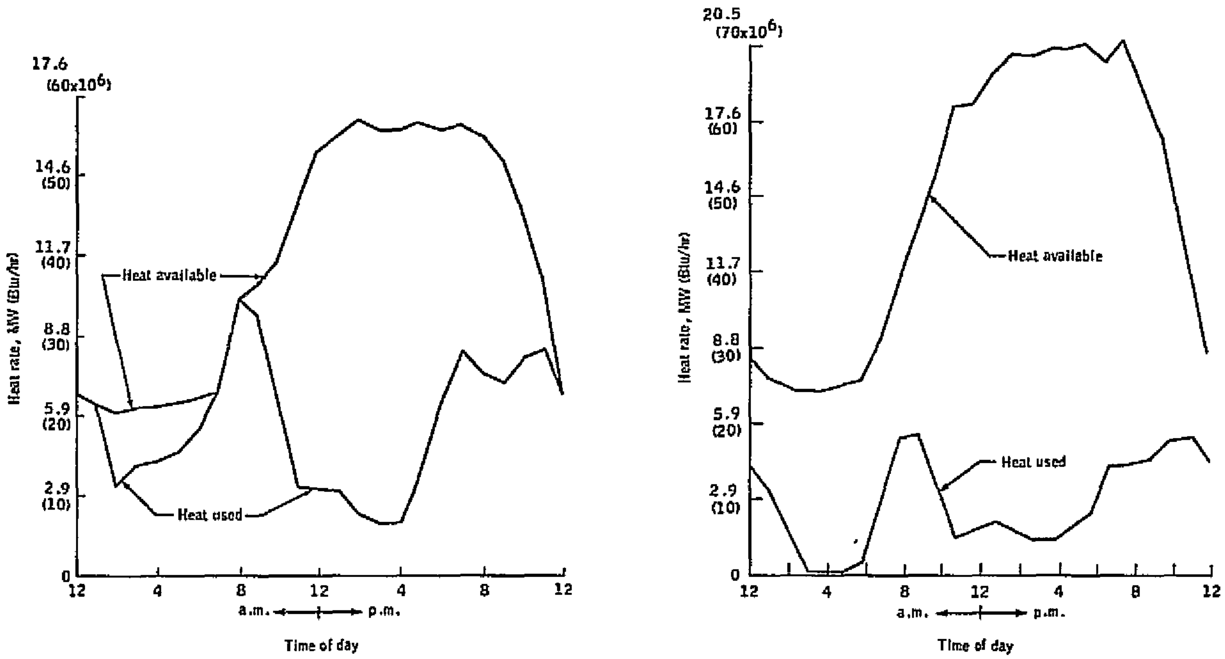
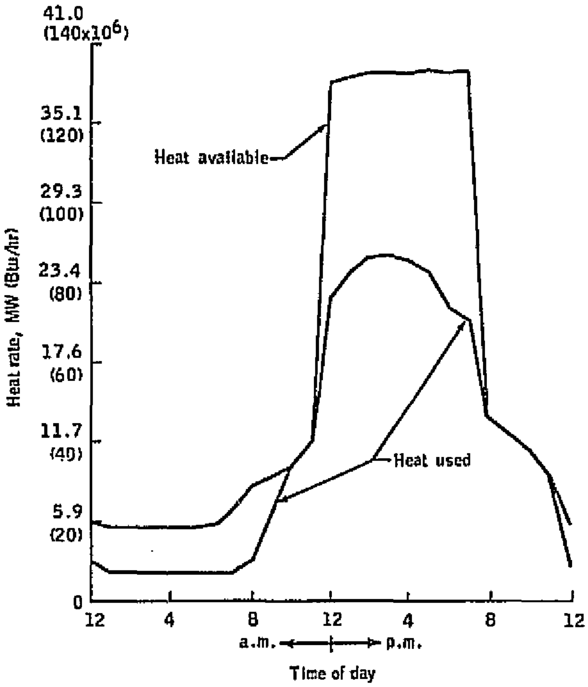


Figure C-27.- The CBD MIUS thermal efficiency.

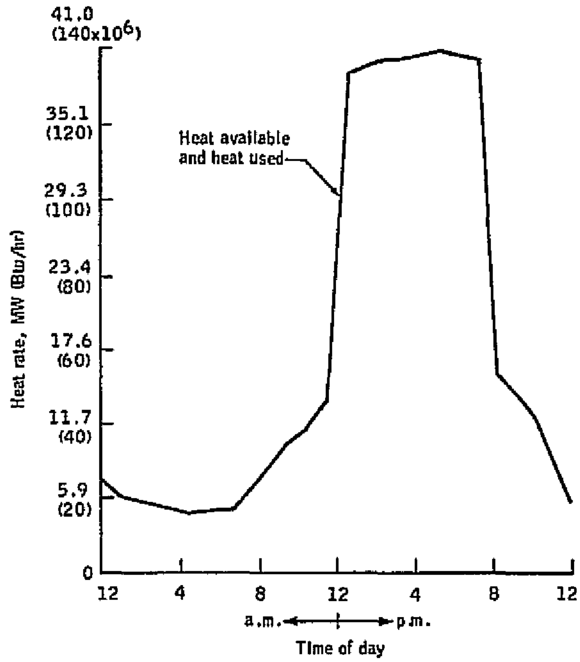


(a) Winter. (b) Summer.

Figure C-28.- The CBD MIUS low-grade heat availability and utilization (based on average weather and floating air-conditioning).

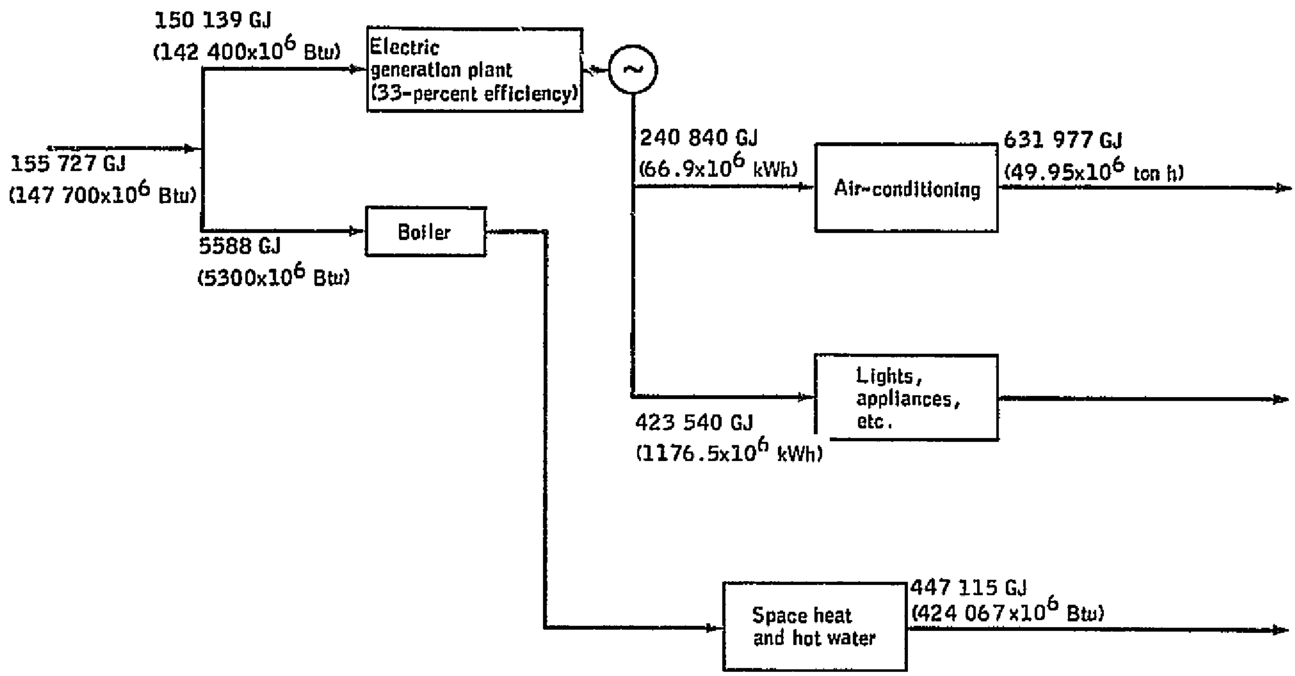


(a) Winter.

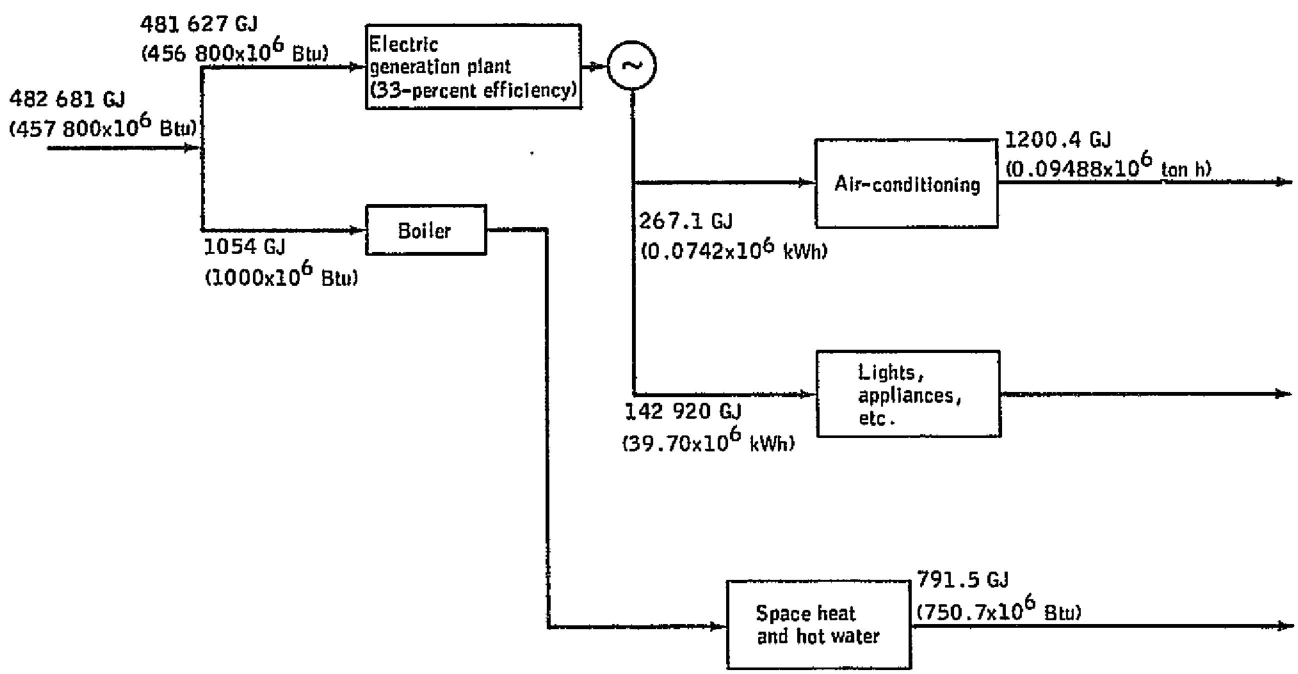


(b) Summer.

Figure C-29.- The CBD MIUS high-grade heat availability and utilization (based on average weather and floating air-conditioning).

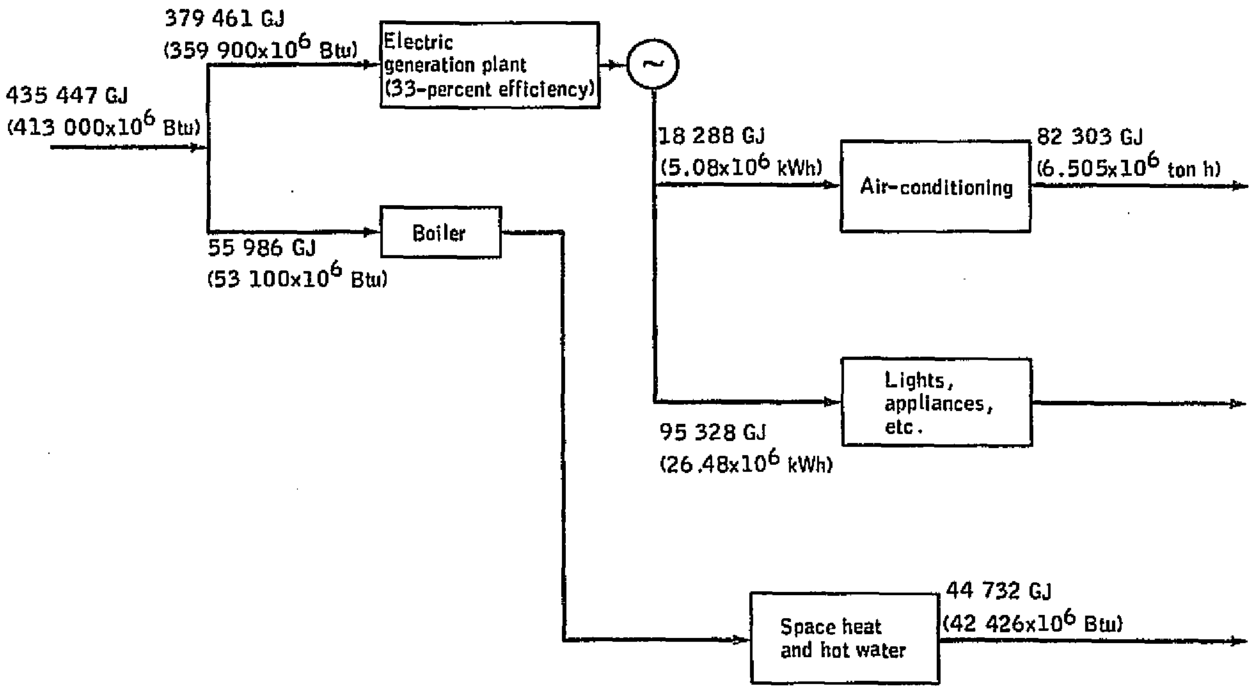


(a) Total community.

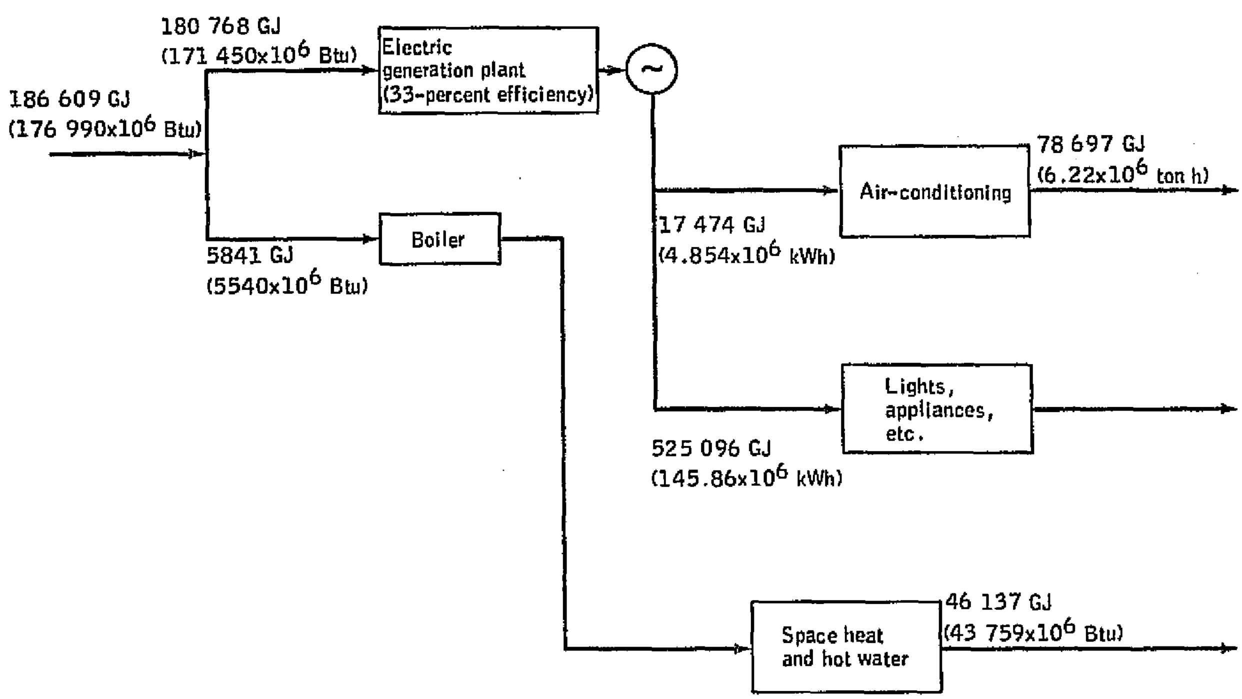


(b) Neighborhood.

Figure C-30.- Annual energy utilization for a conventional system.

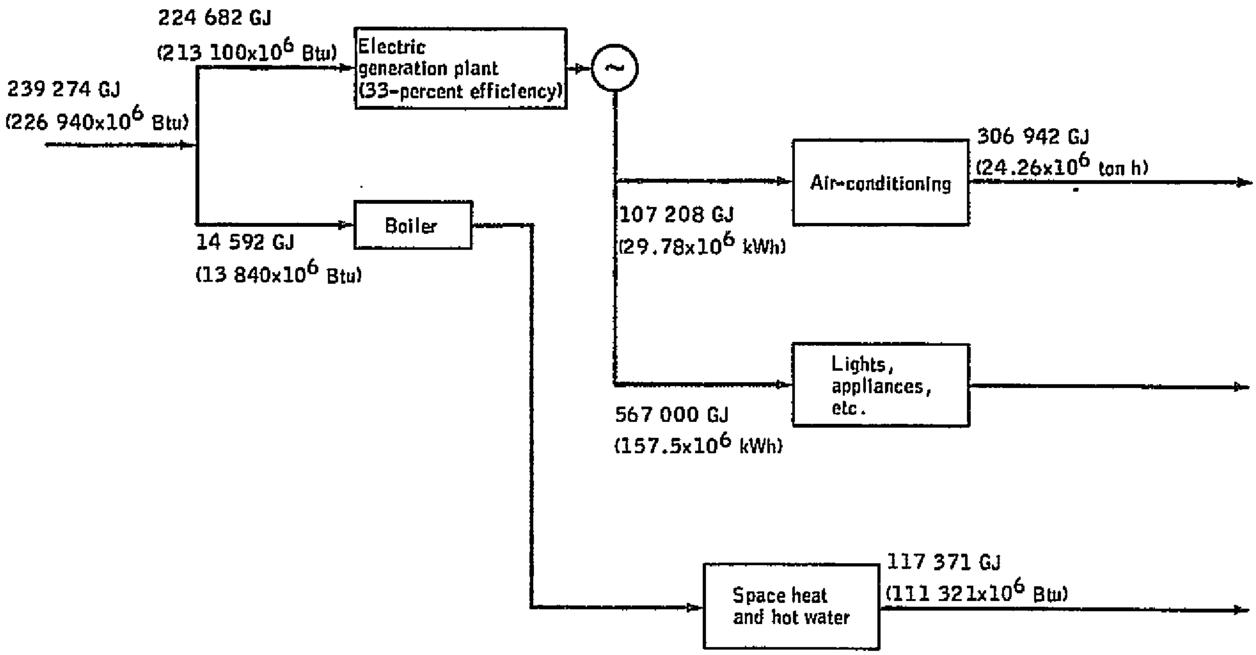


(c) Village center.



(d) Village complex.

Figure C-30.- Continued.



(e) The CBD.

Figure C-30.- Concluded.

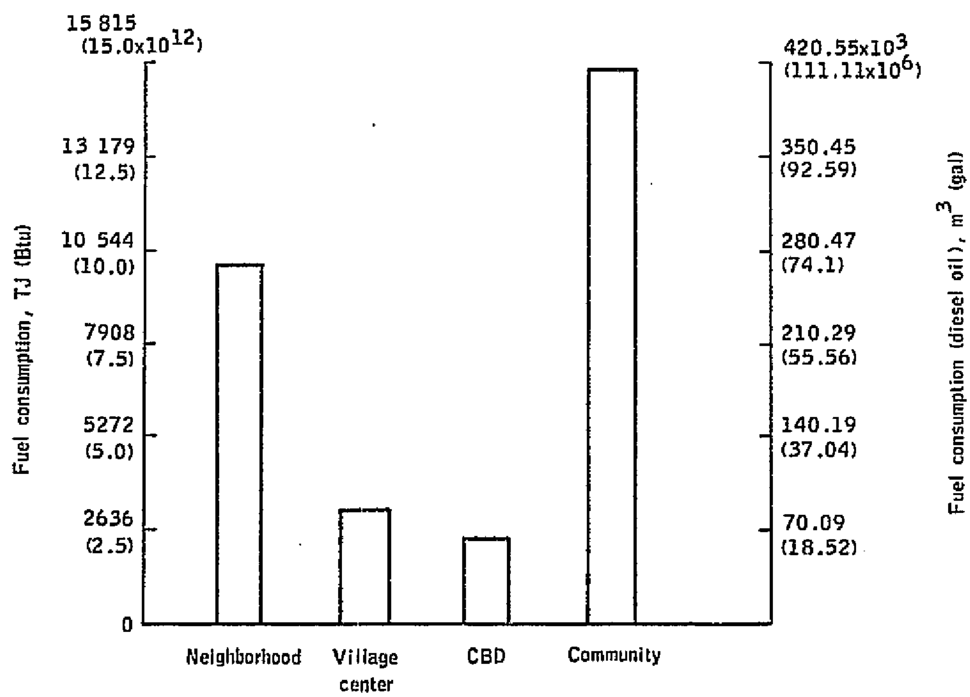


Figure C-31.- Annual fuel consumption for a conventional system at the 20-year point.

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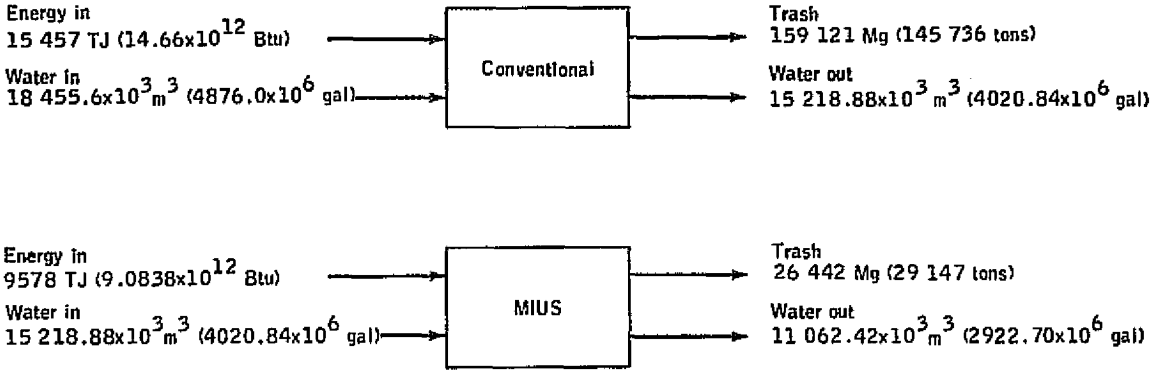


Category	Savings, percent
Water savings	17.5
Effluent reduction	27.3
Trash load reduction	80.0
Annual energy savings	38.04

Figure C-32.- Comparison of annual figures for the 8-MIUS option total community and a conventional system at the 20-year point.

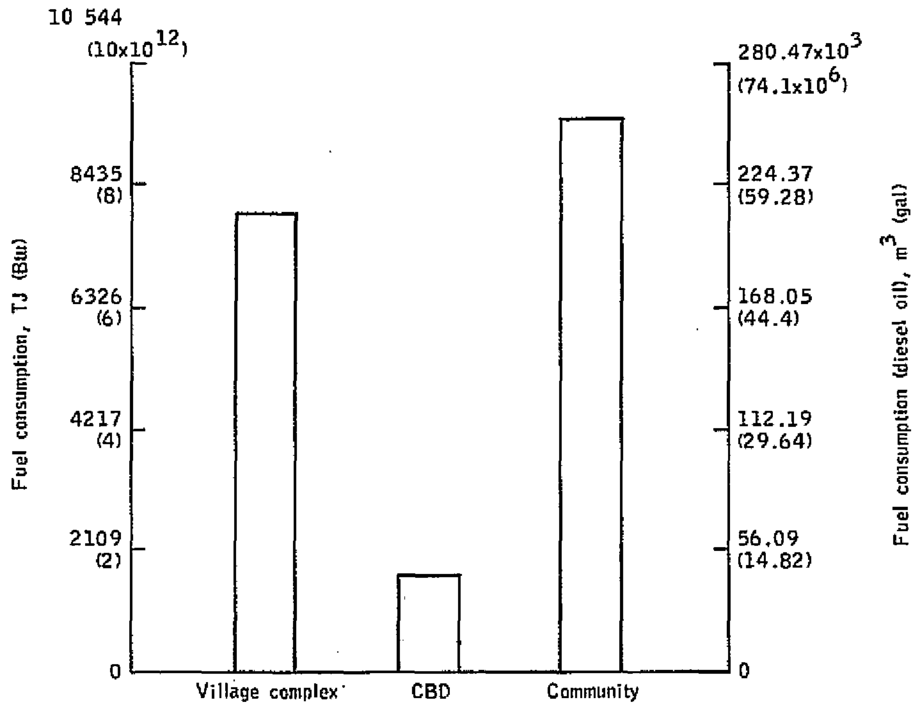


Figure C-33.- Annual fuel consumption for the 8-MIUS option at the 20-year point.

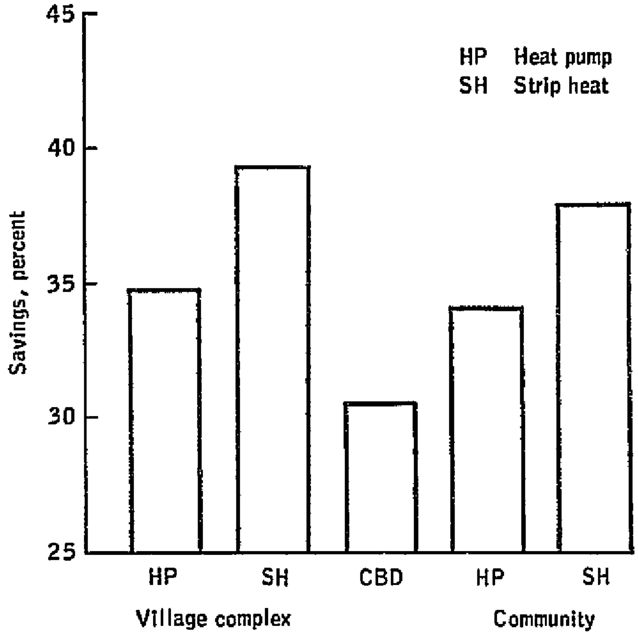


Figure C-34.- Annual fuel savings of the 8-MIUS option at the 20-year point as compared to a conventional system.

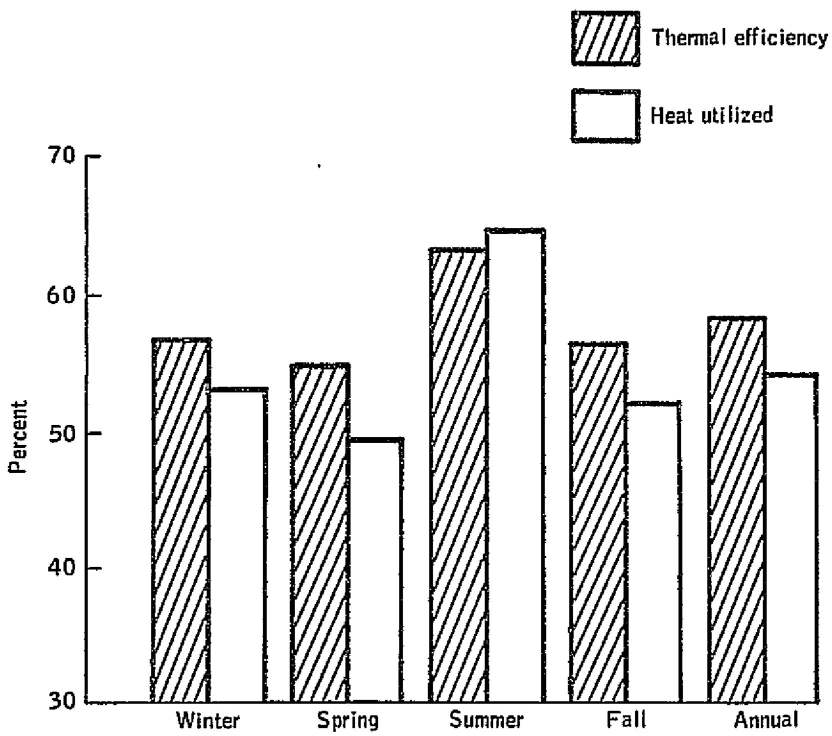


Figure C-35.- Community 8-MIUS option thermal efficiency at the 20-year point.

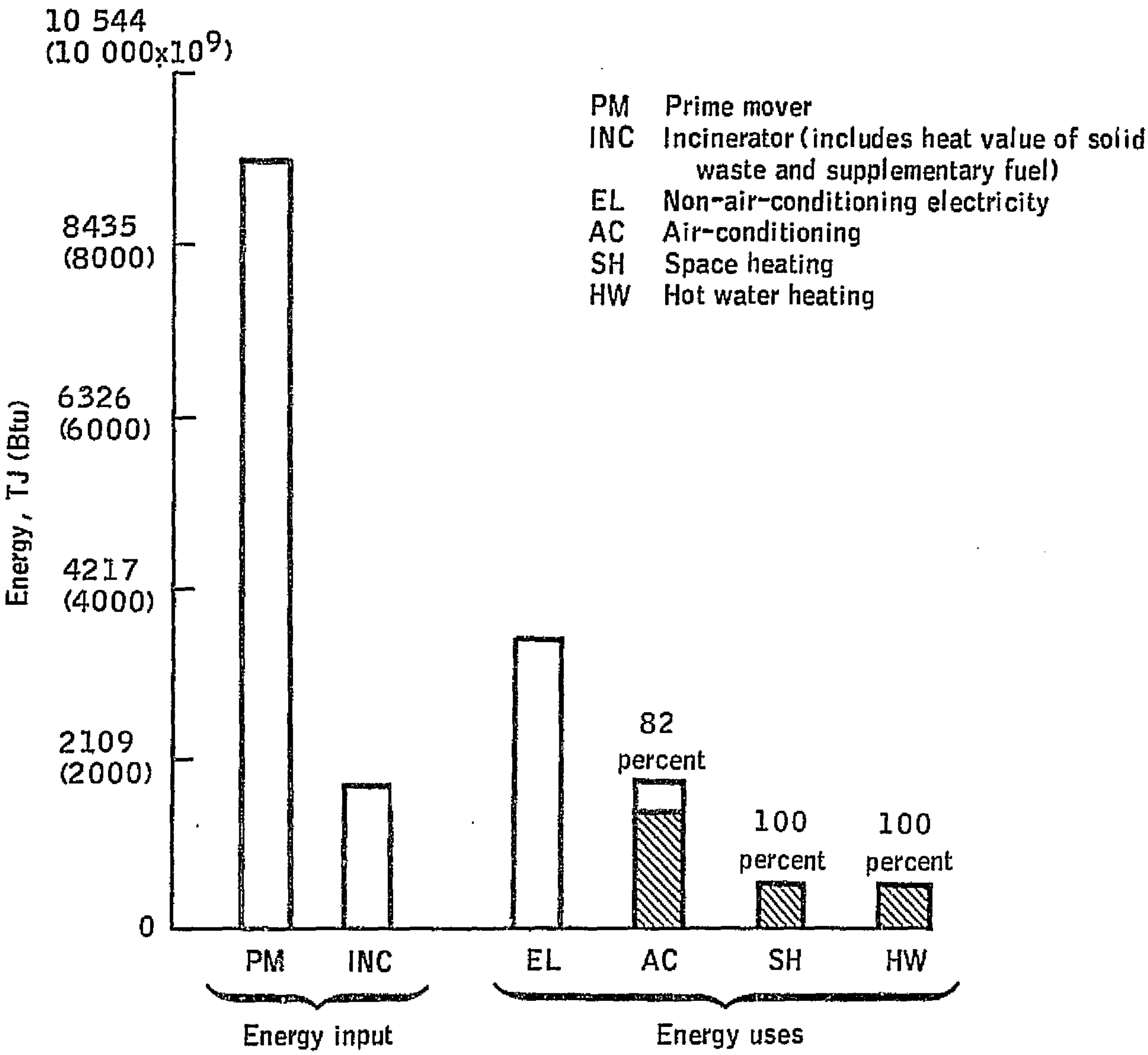
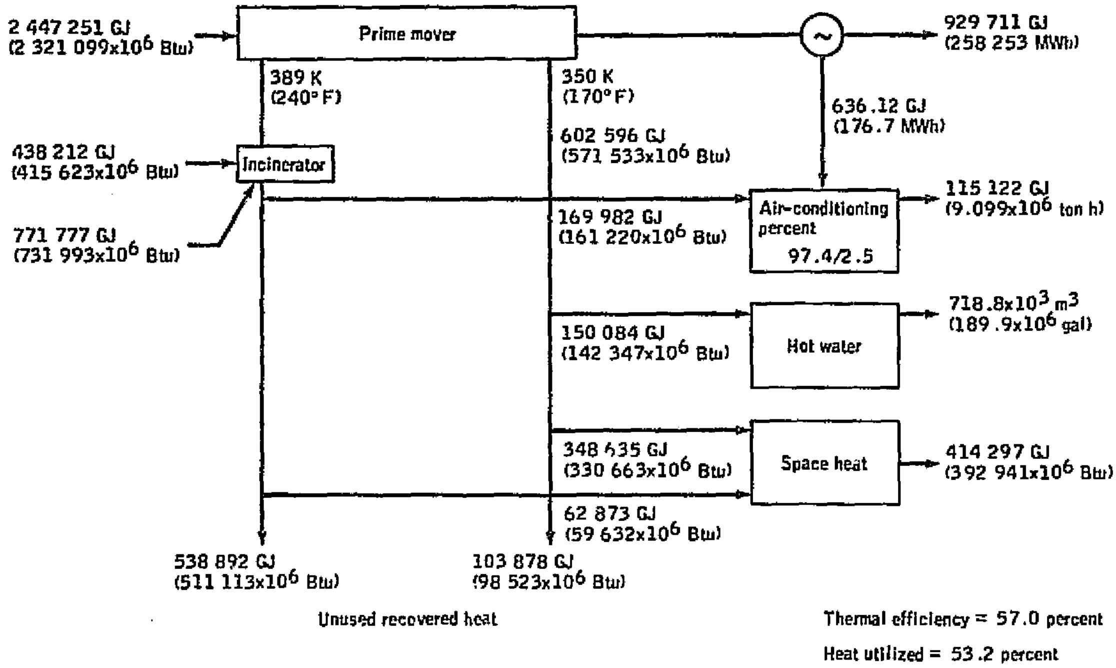
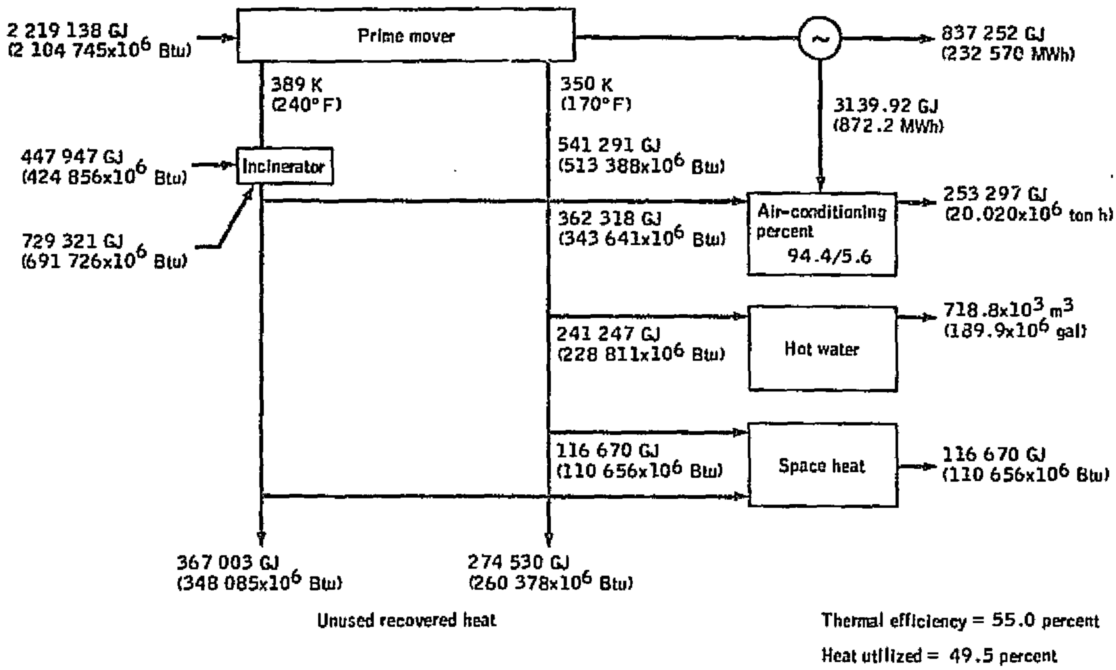


Figure C-36.- Bar chart showing community 8-MIUS option annual energy utilization at the 20-year point.

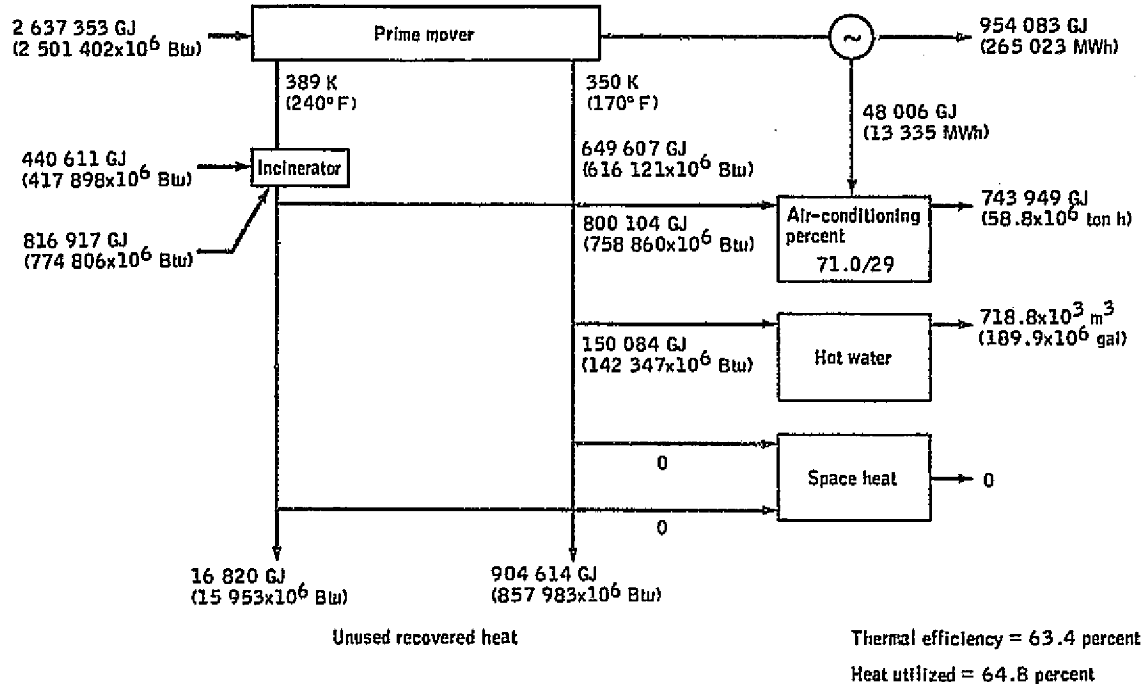


(a) Winter.

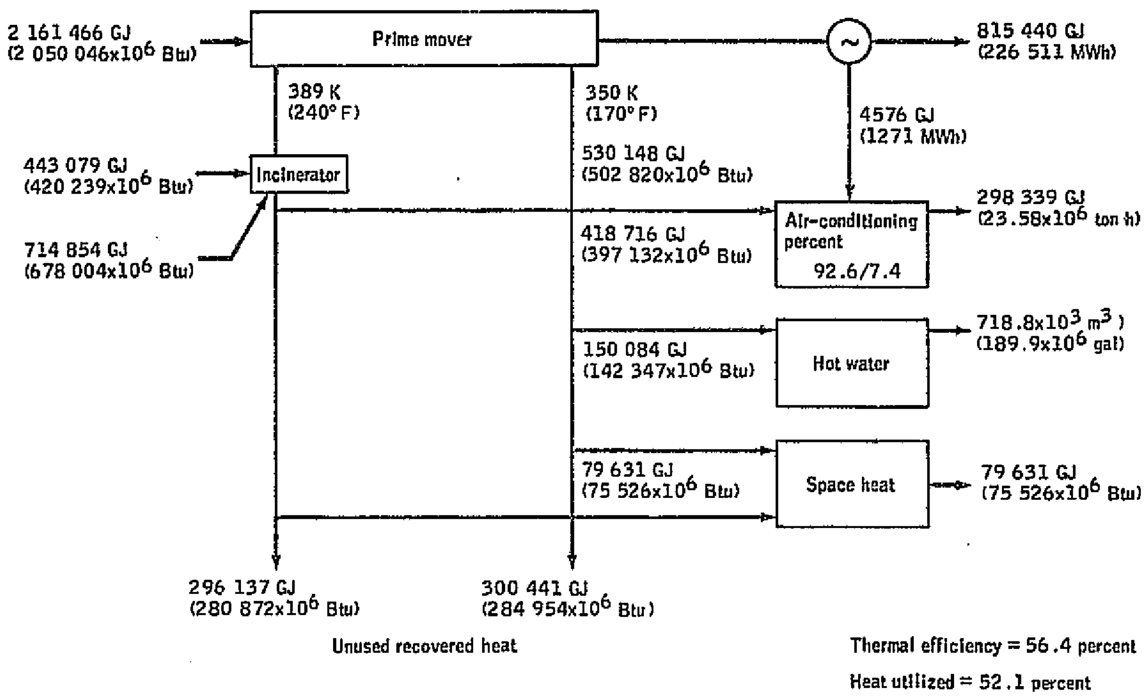


(b) Spring.

Figure C-37.- The community 8-MIUS option energy utilization at the 20-year point.

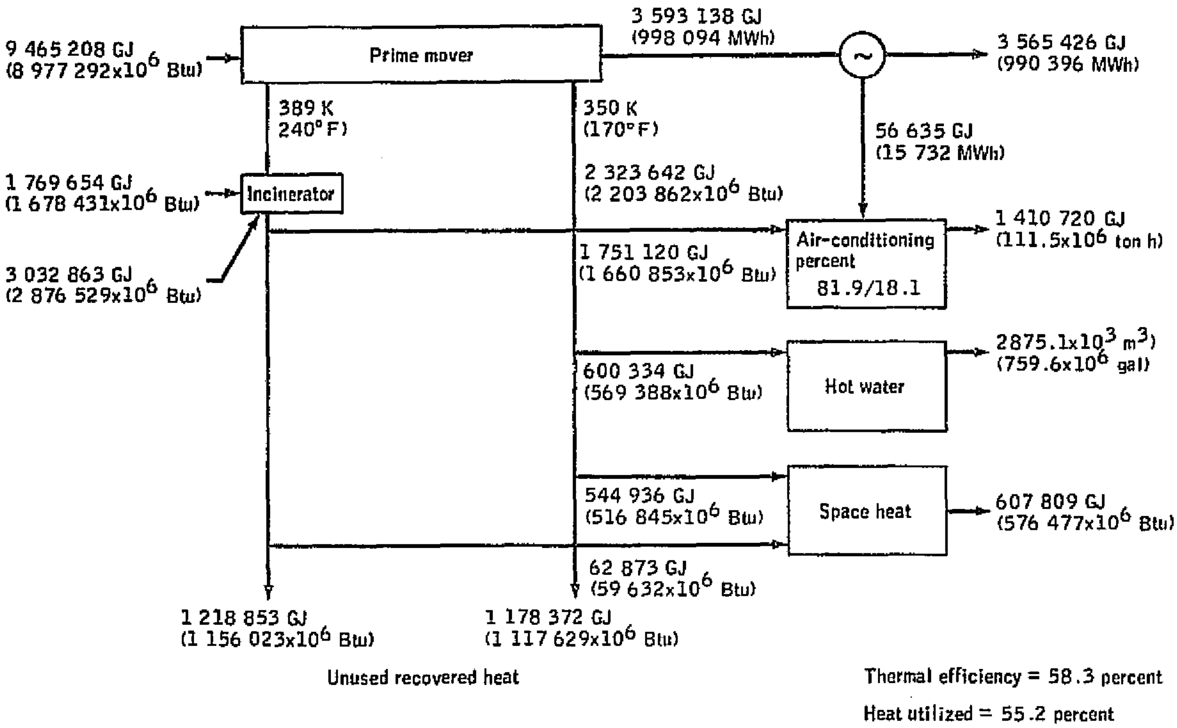


(c) Summer.



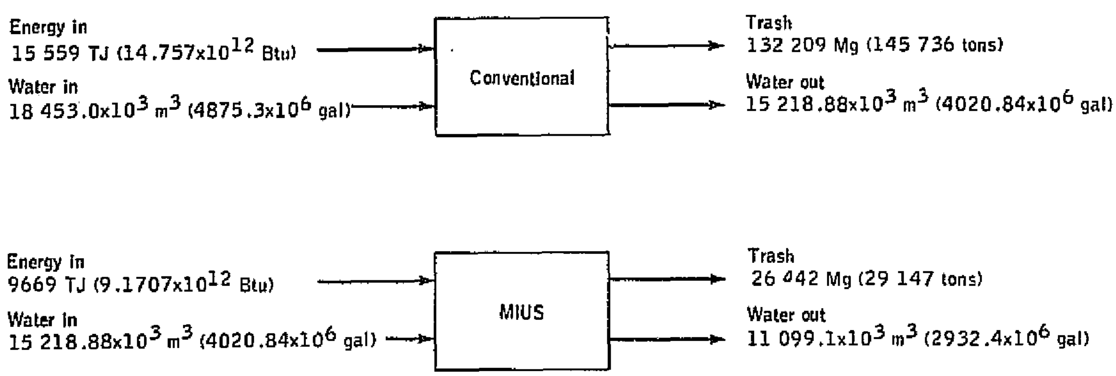
(d) Fall.

Figure C-37.- Continued.



(e) Annual season.

Figure C-37.- Concluded.



Category	Savings, percent
Water savings	17.5
Effluent reduction	27.1
Trash load reduction	80.0
Annual energy savings	37.86

Figure C-38.- Comparison of annual figures for the 29-MIUS option total community and a conventional system at the 20-year point.

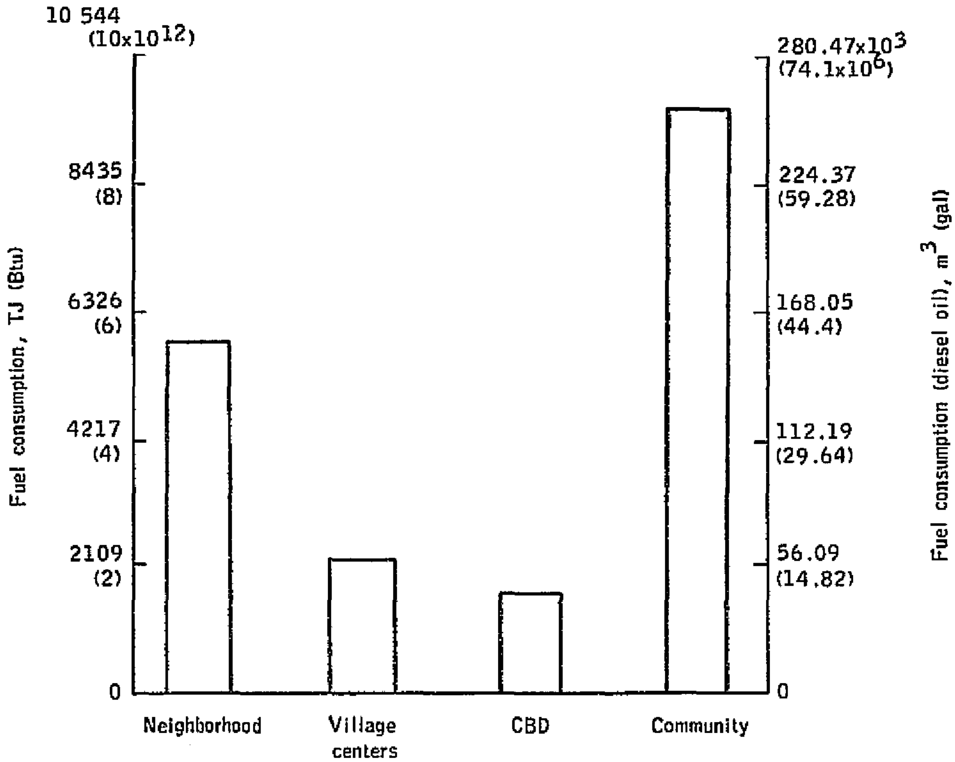


Figure C-39.- Annual fuel consumption for the 29-MIUS option at the 20-year point.

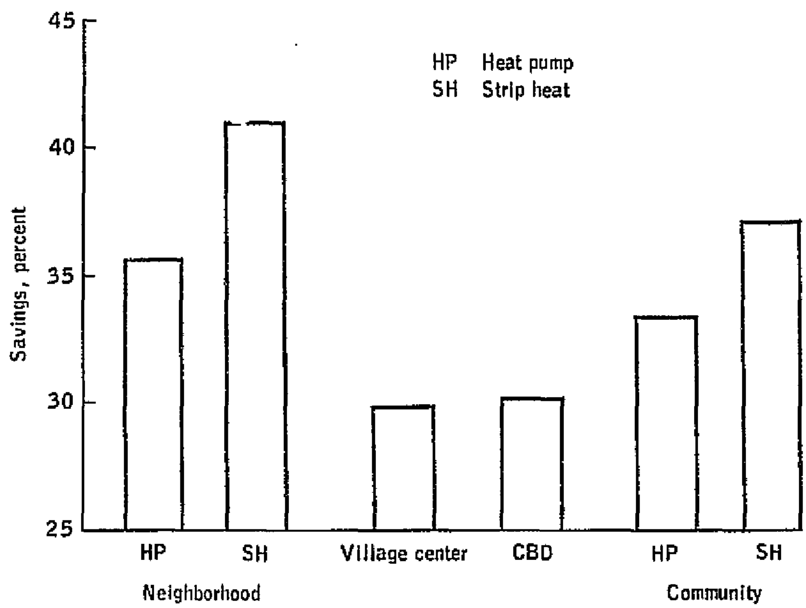


Figure C-40.- Annual fuel savings for the 29-MIUS option at the 20-year point as compared to a conventional system.

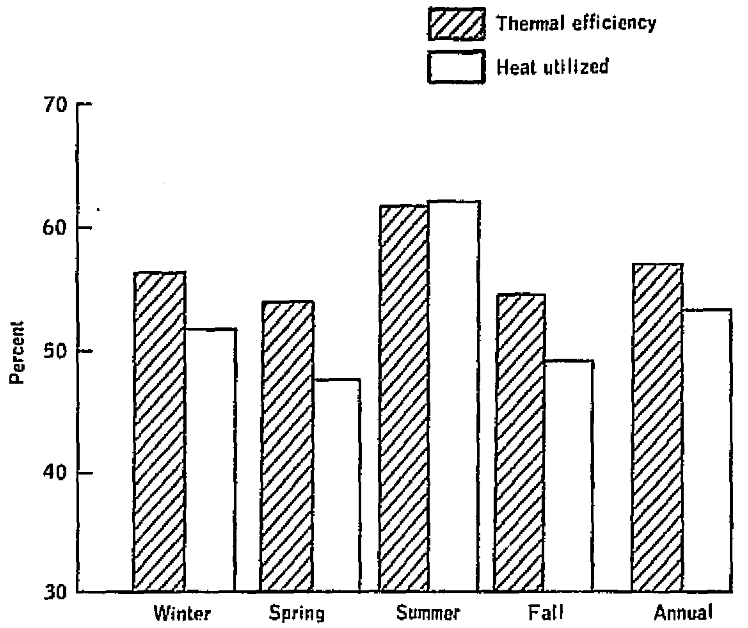


Figure C-41.- Community 29-MIUS option thermal efficiency at the 20-year point.

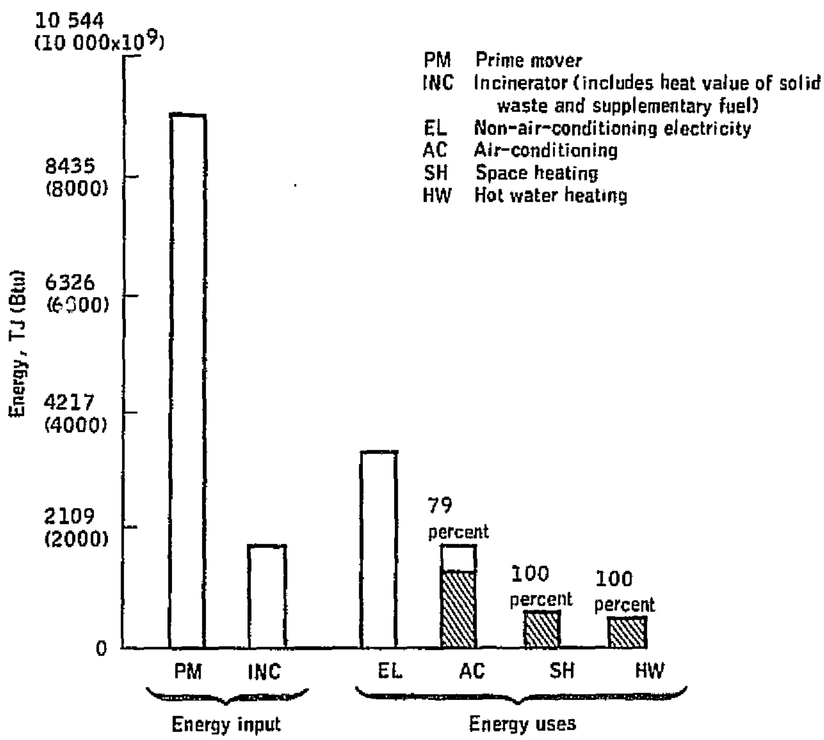
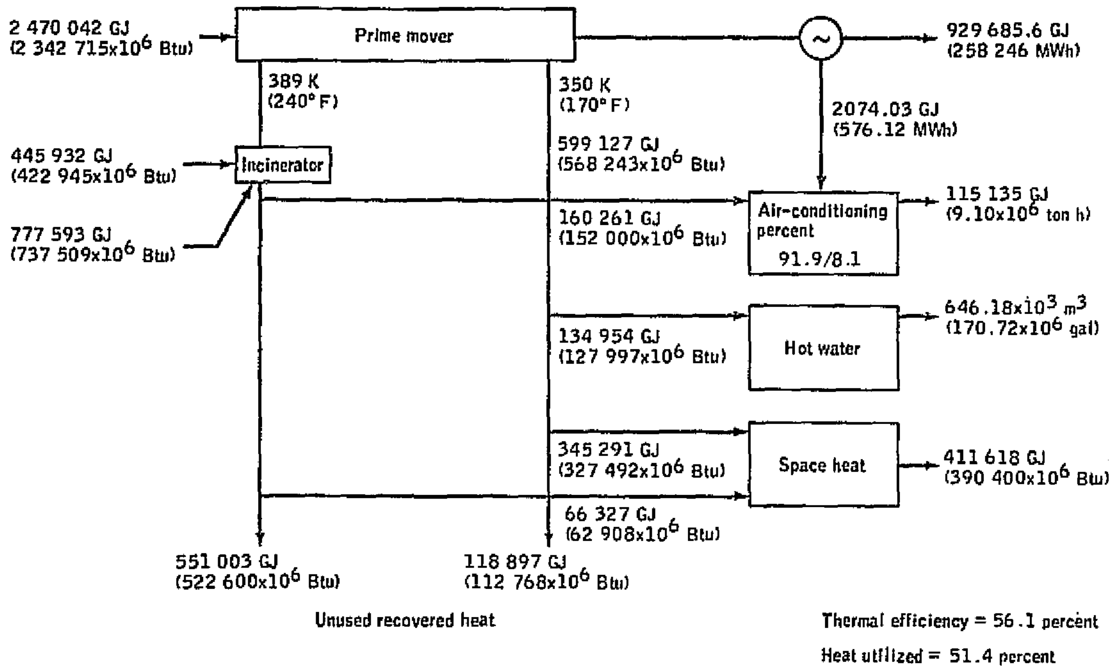
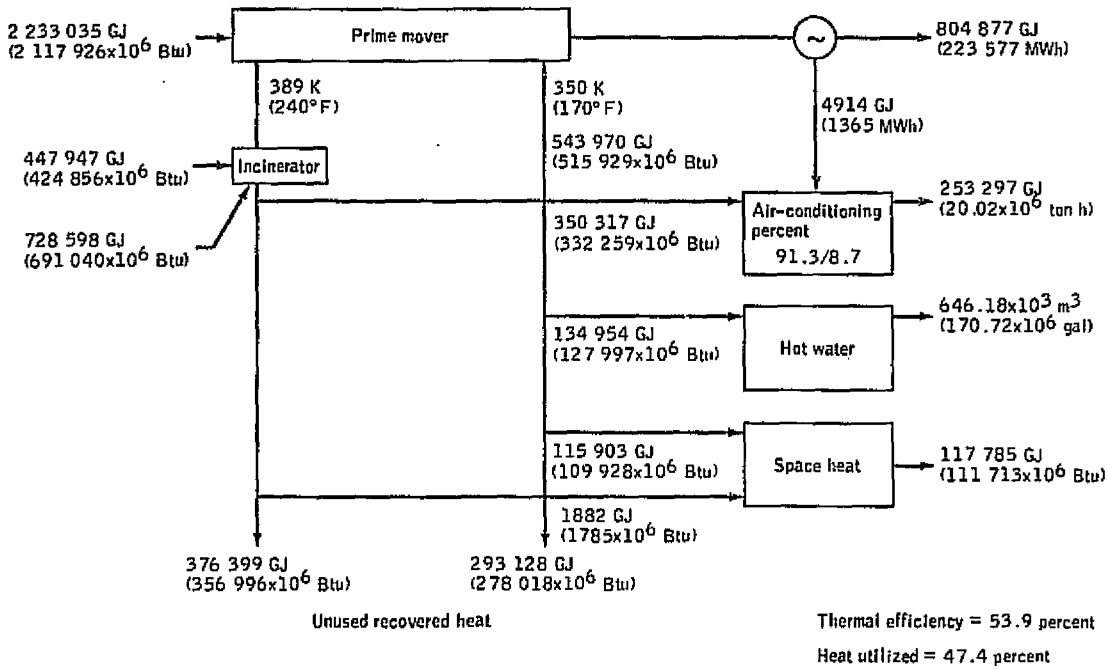


Figure C-42.- Bar chart showing community 29-MIUS option annual energy utilization at the 20-year point.

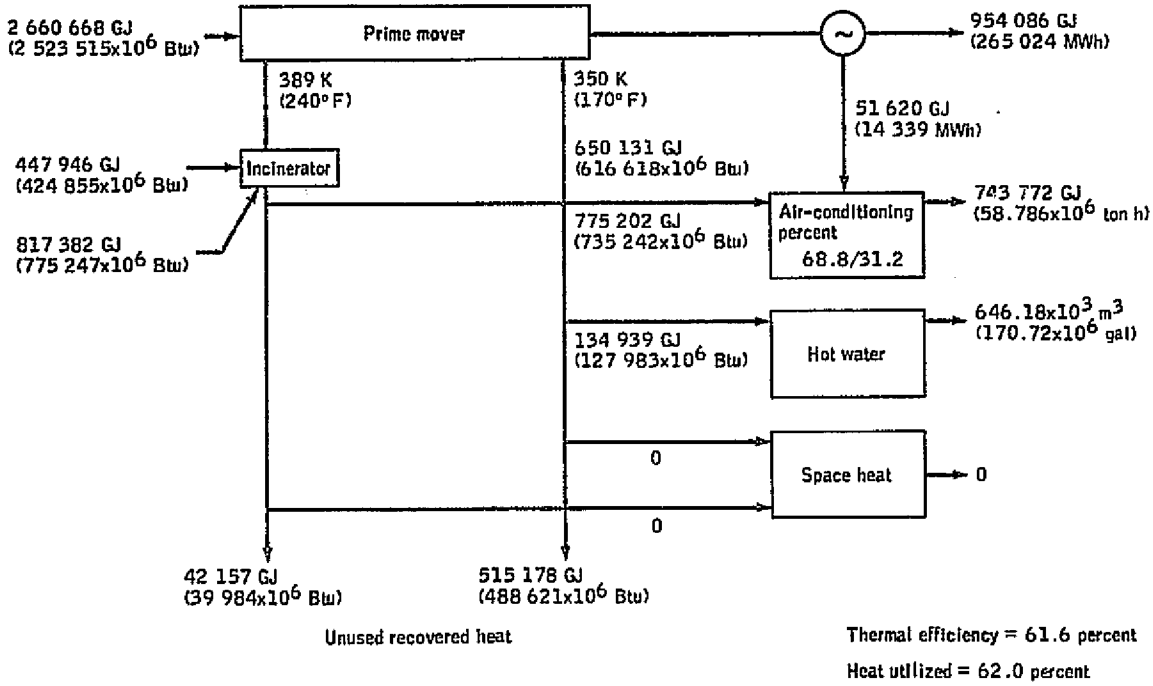


(a) Winter.

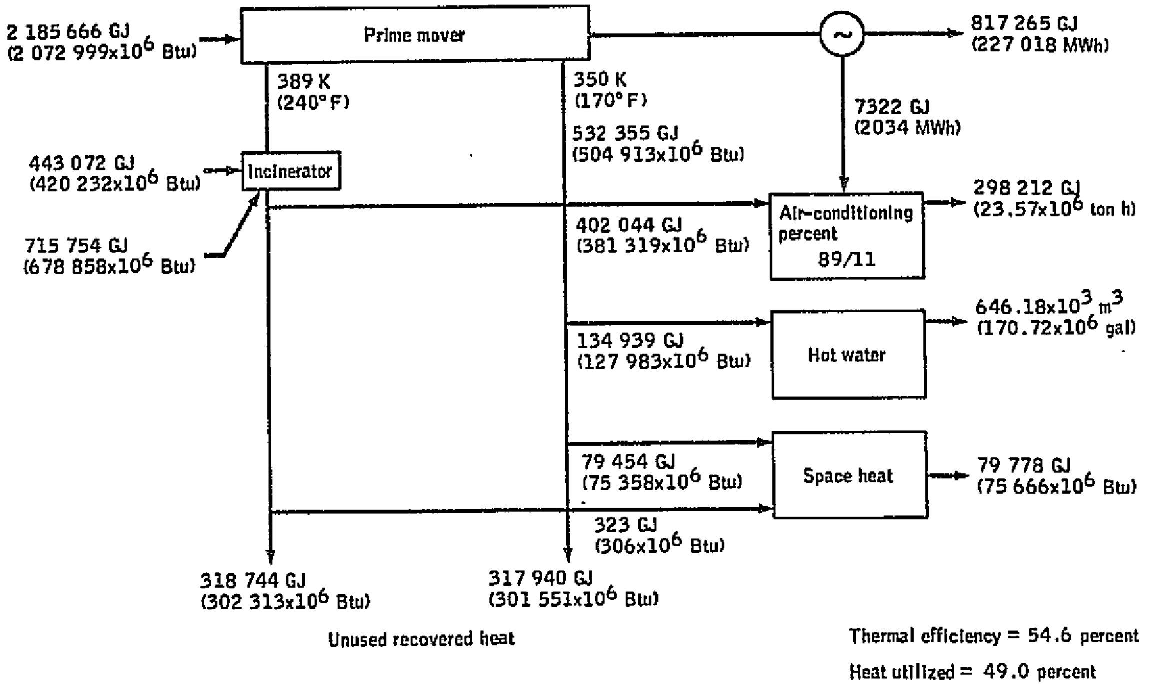


(b) Spring.

Figure C-43.- The 29-MIUS option community energy utilization at the 20-year point.



(c) Summer.



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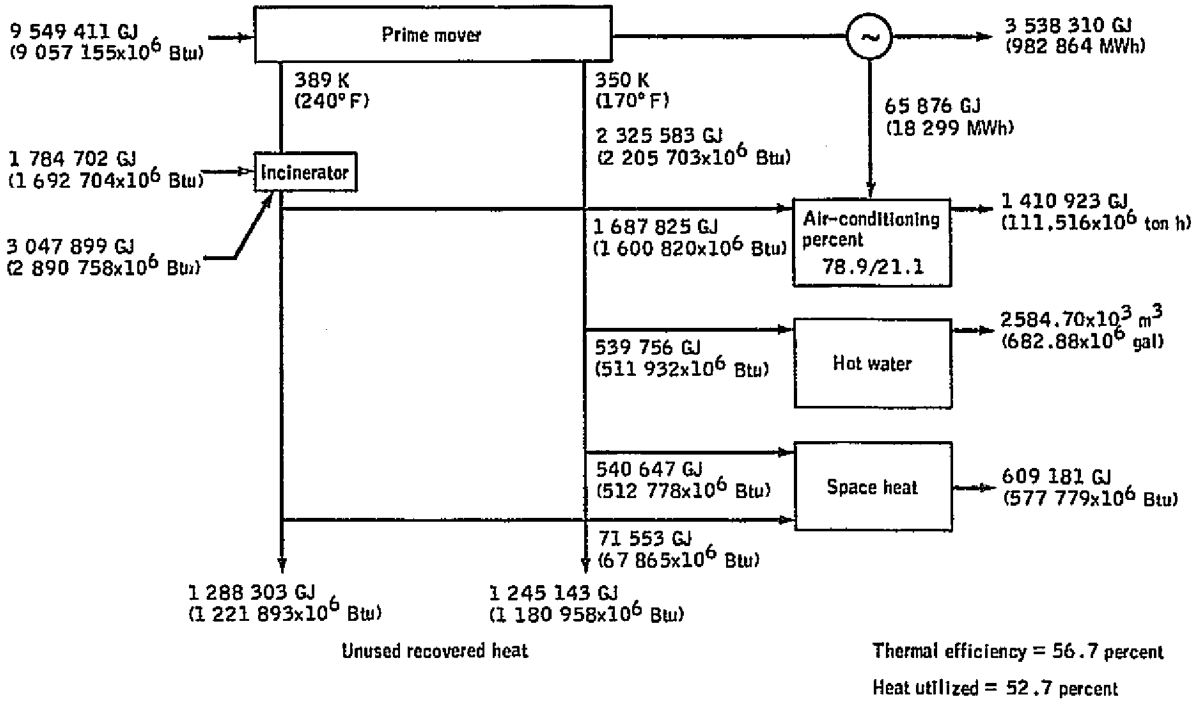
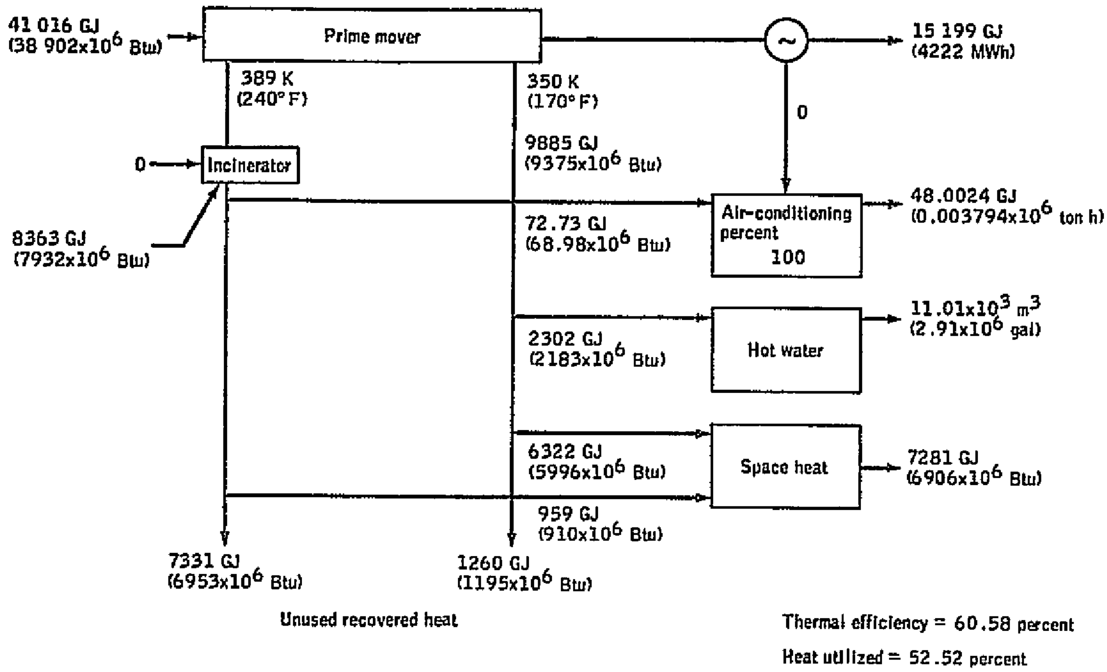
(d) Fall.

Figure C-43.- Continued.

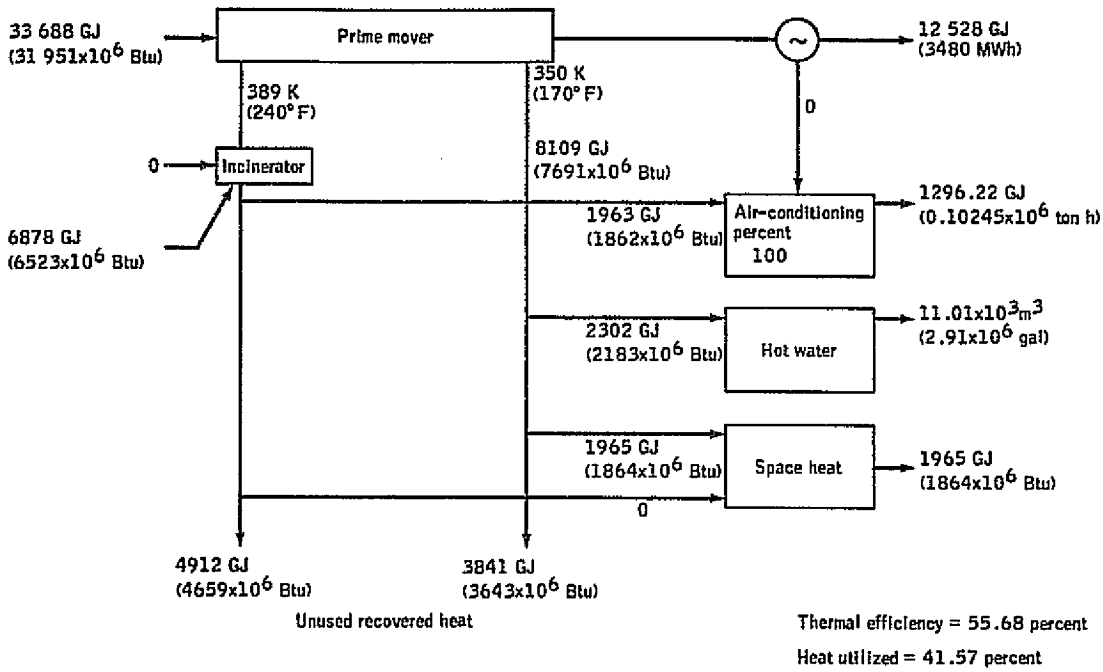


(e) Annual season.

Figure C-43.- Concluded.

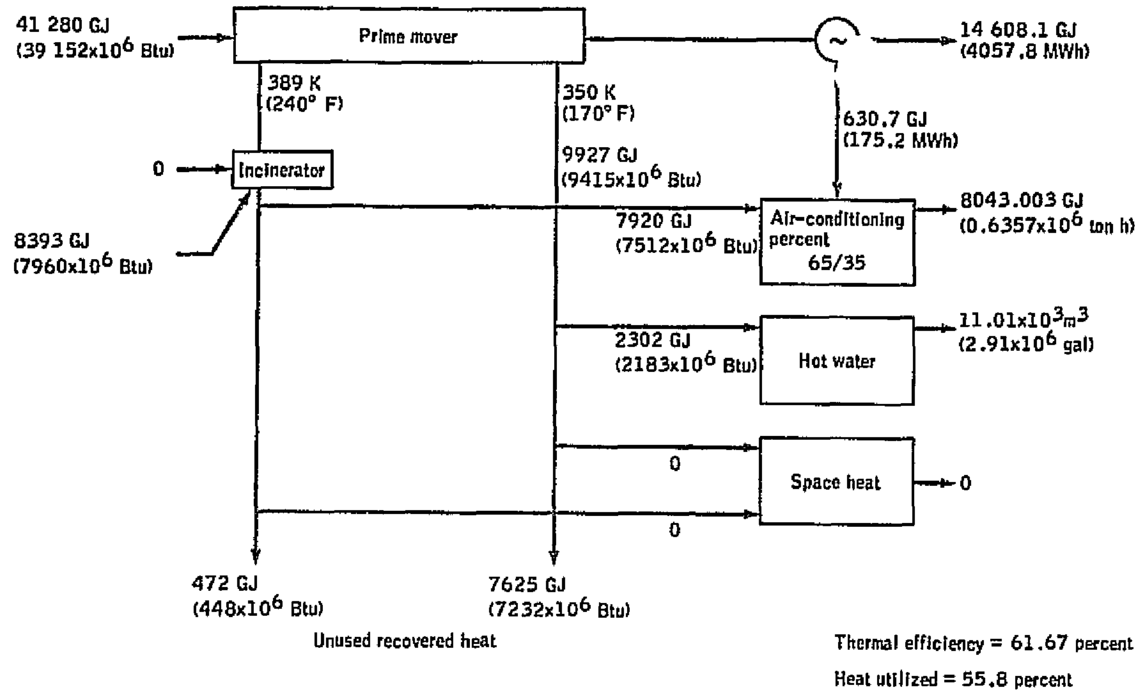


(a) Winter.

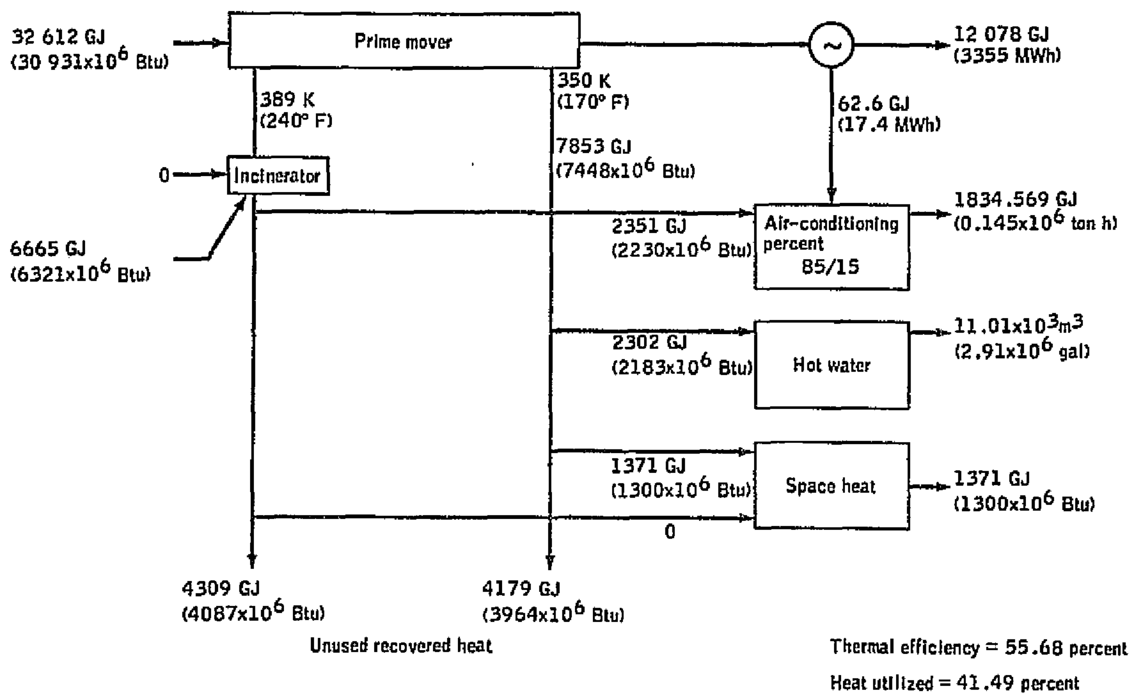


(b) Spring.

Figure C-44.- Neighborhood energy utilization for the 2d year of the 4-year development.

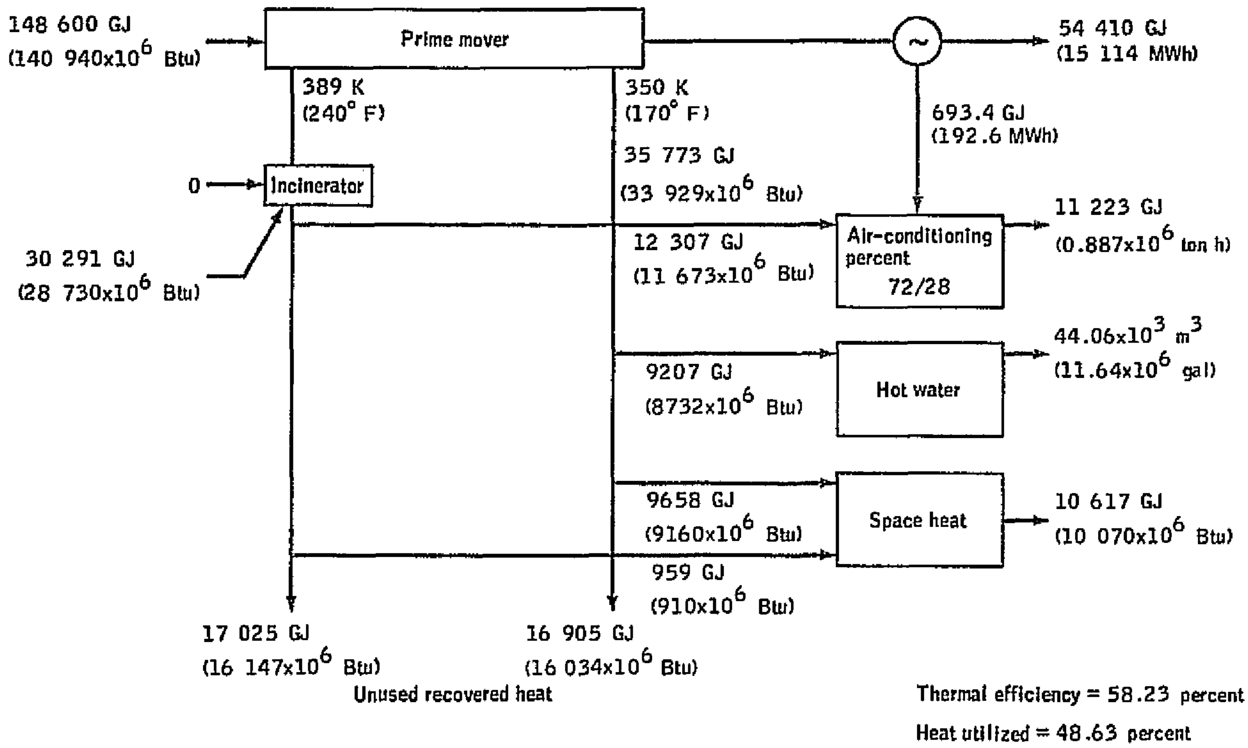


(c) Summer.



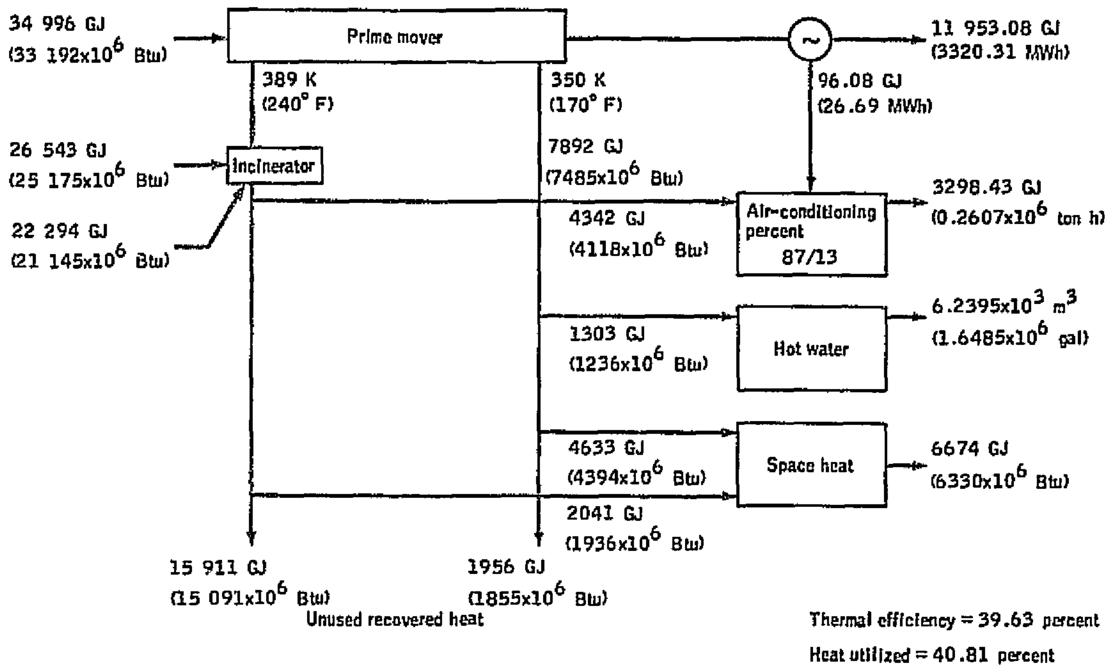
(d) Fall.

Figure C-44.- Continued.

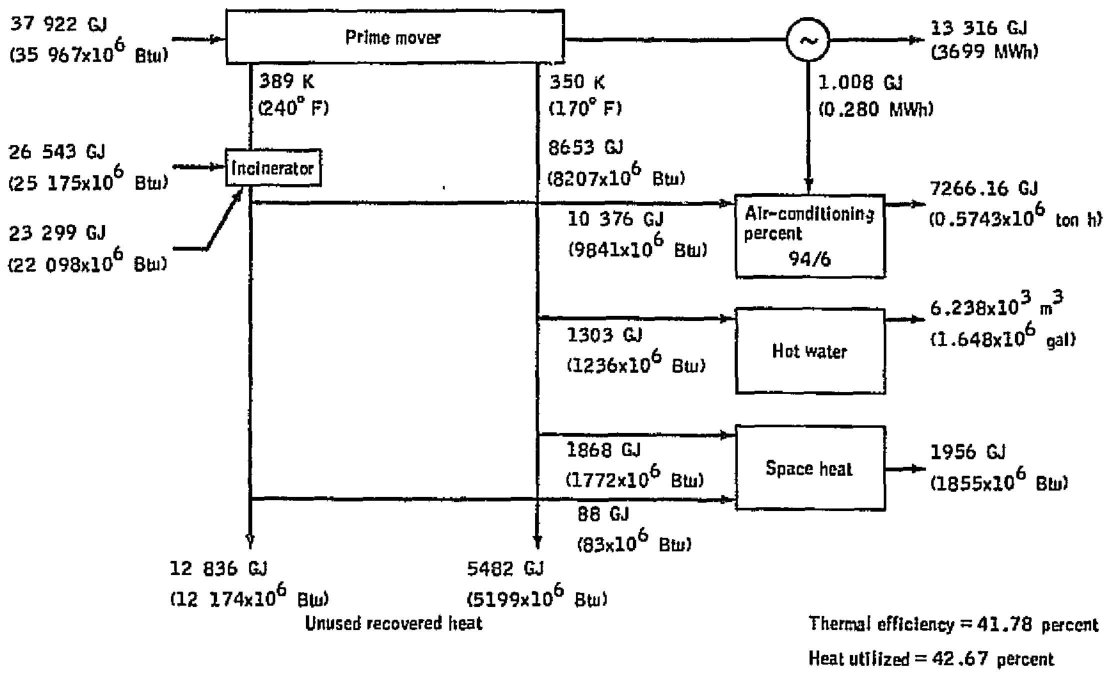


(e) Annual season.

Figure C-44.- Concluded.

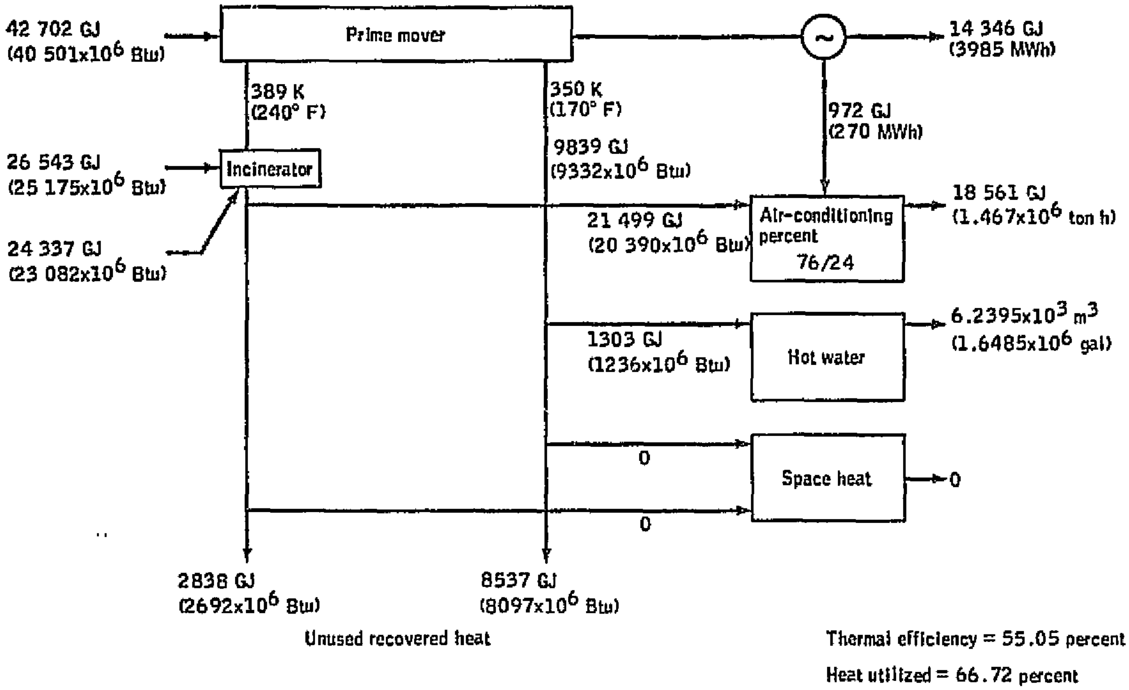


(a) Winter.

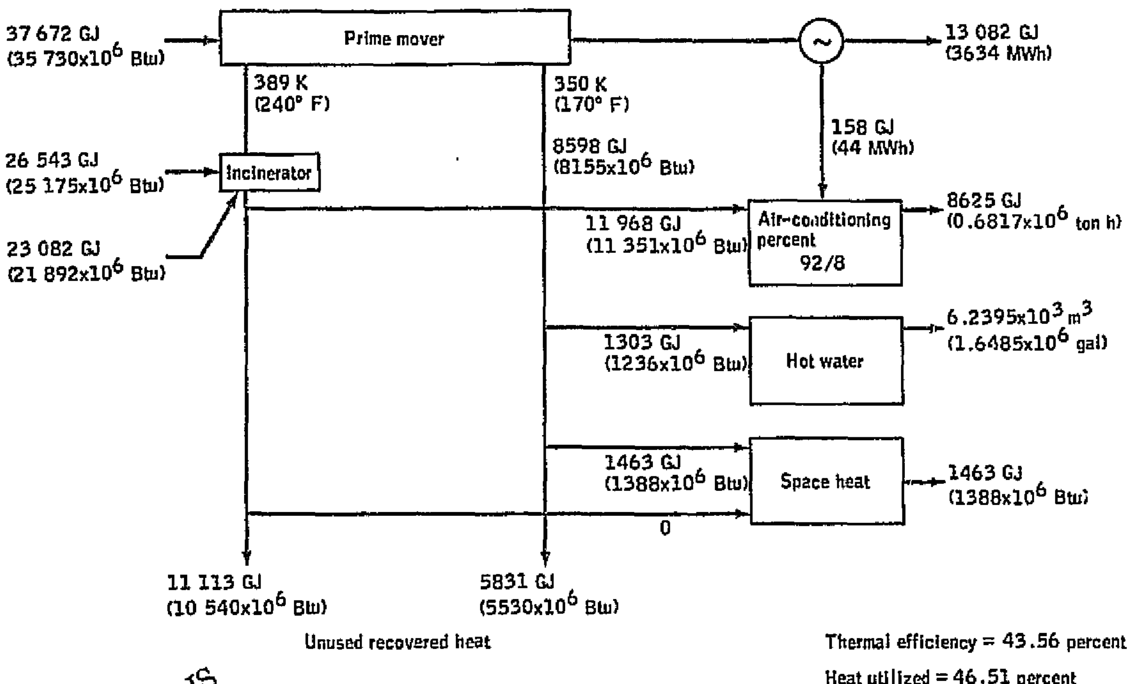


(b) Spring.

Figure C-45.- Village center energy utilization for the 2d year of the 4-year development.

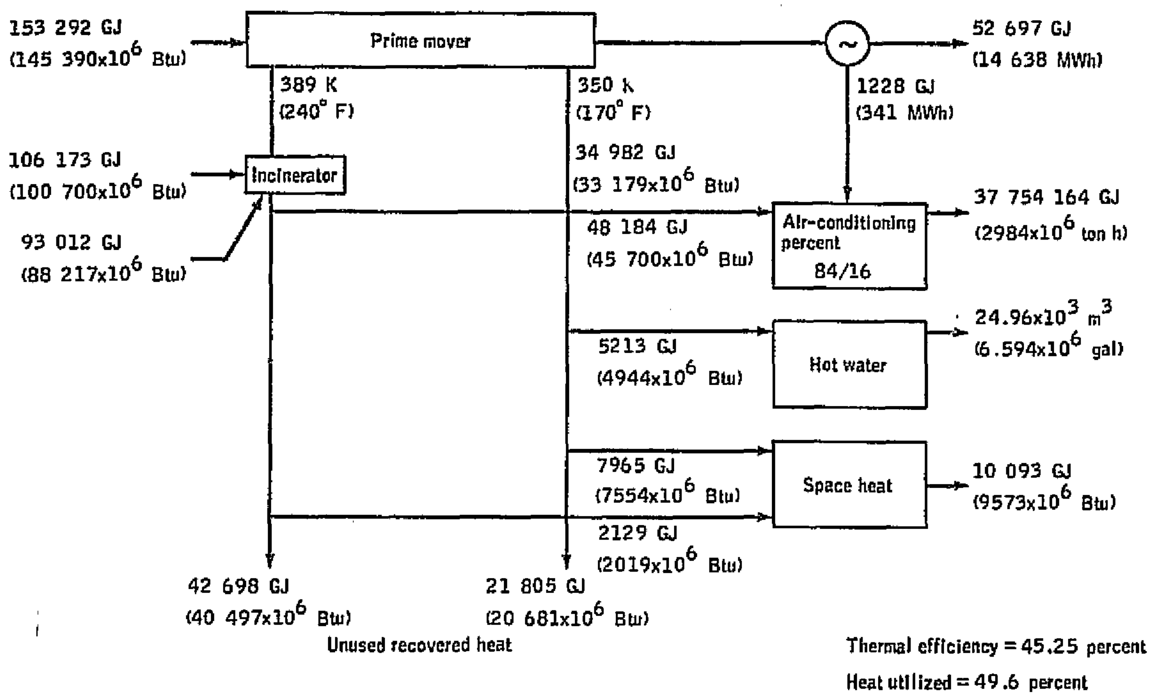


(c) Summer.



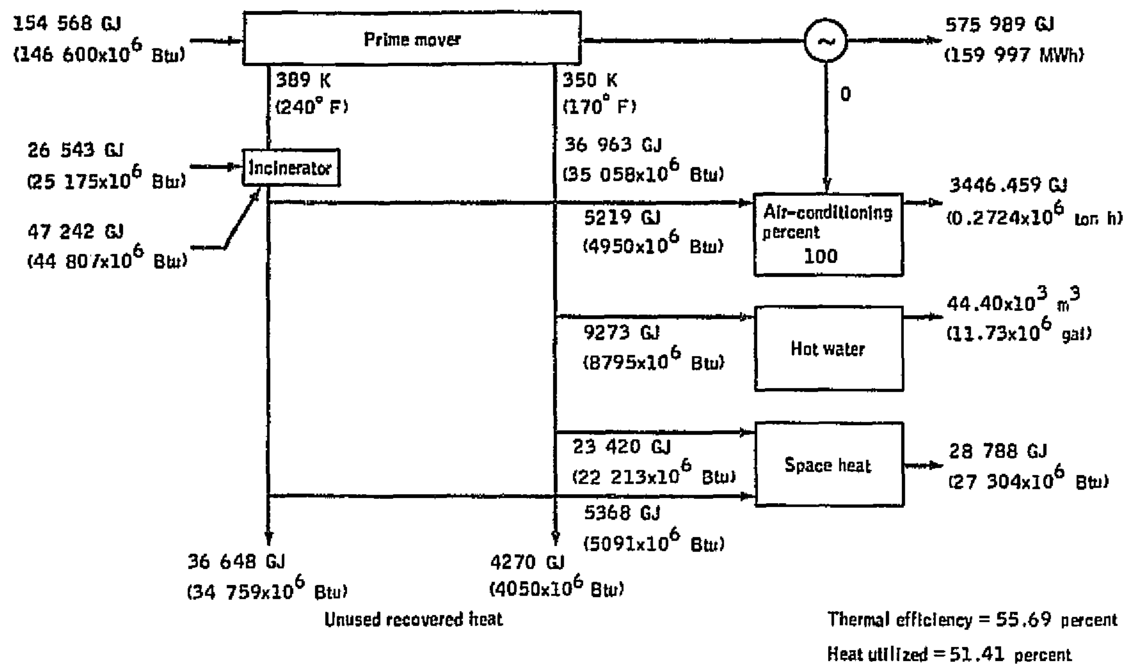
(d) Fall.

Figure C-45.- Continued.

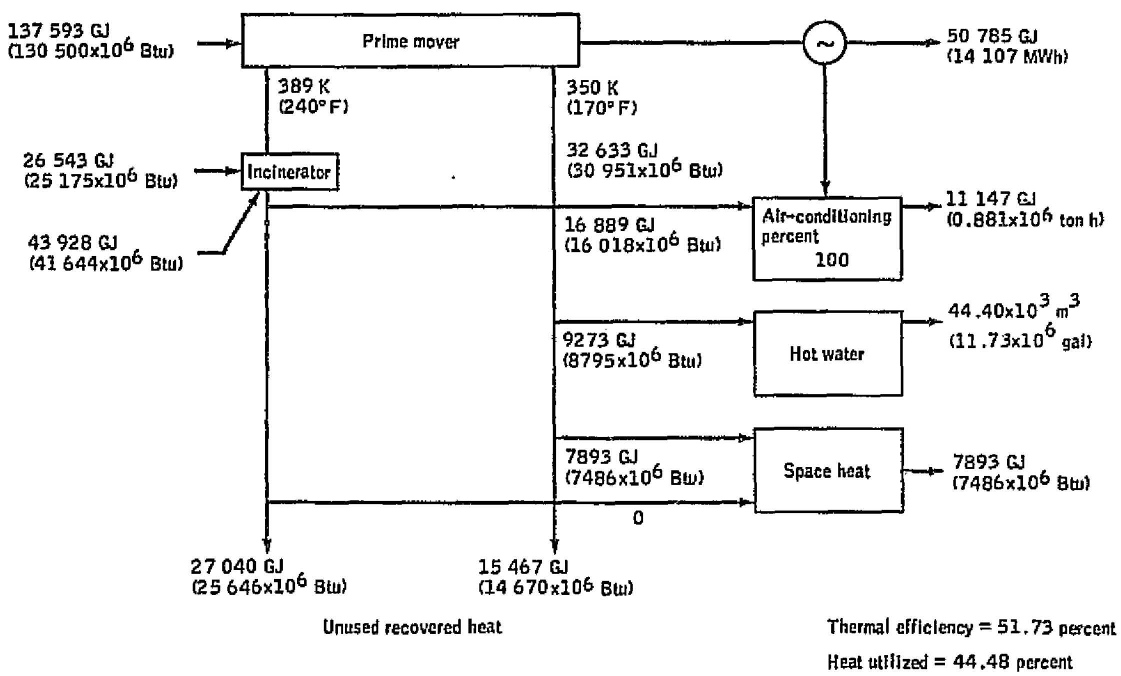


(e) Annual season.

Figure C-45.- Concluded.

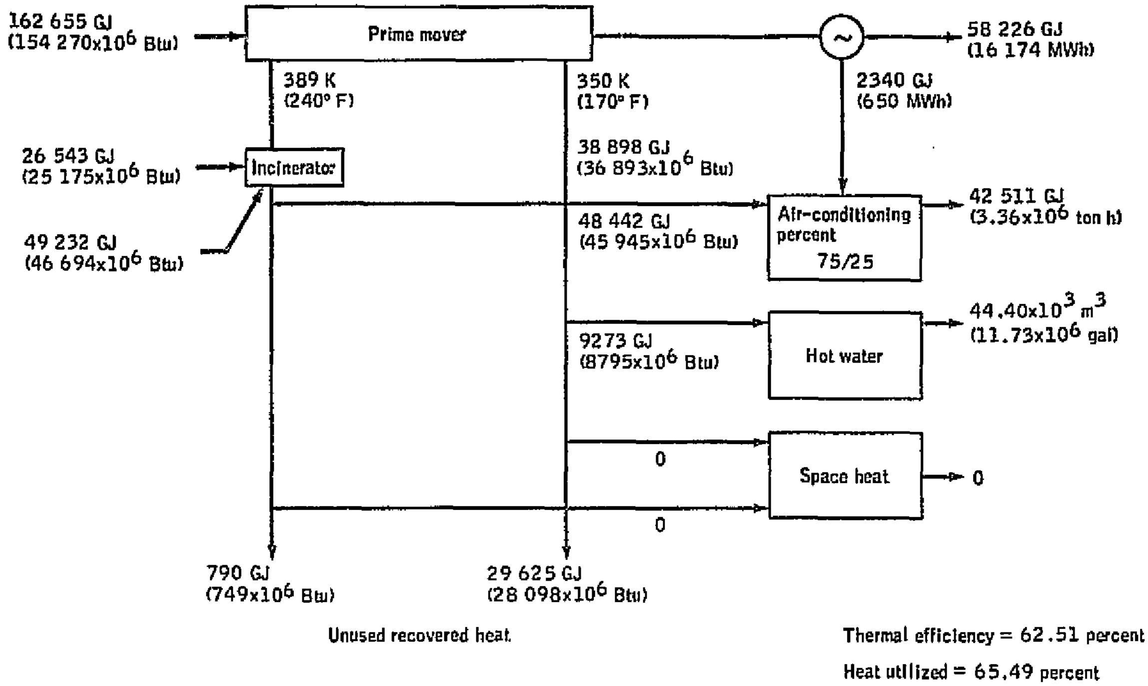


(a) Winter.

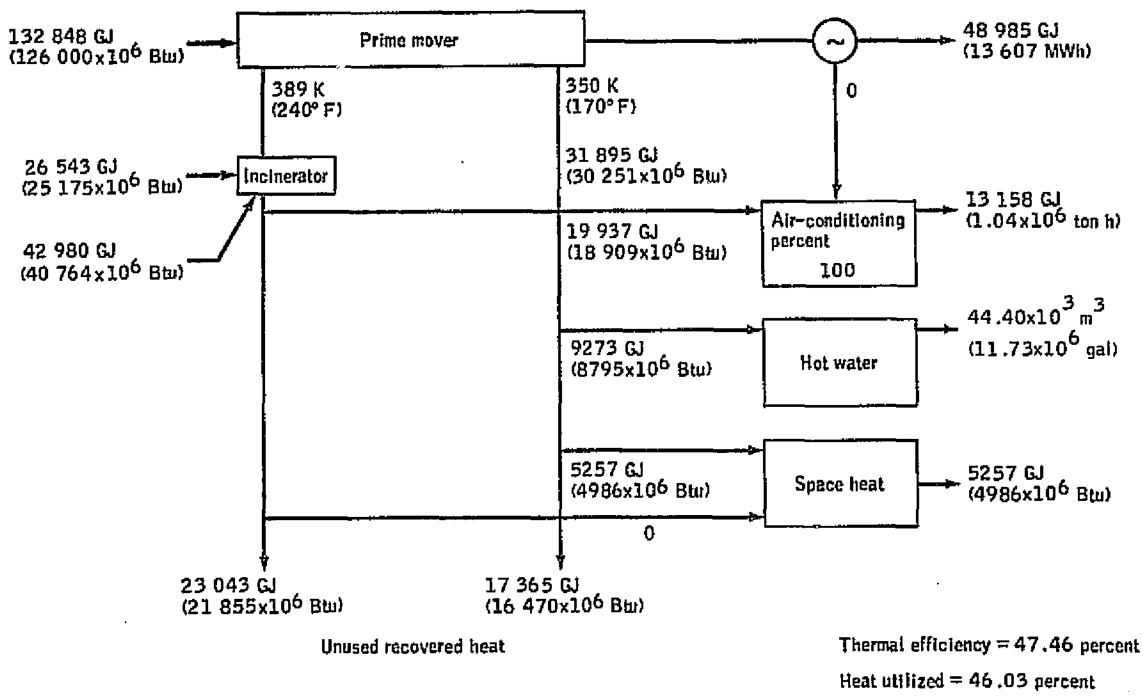


(b) Spring.

Figure C-46.- Village complex energy utilization for the 2d year of the 4-year development.

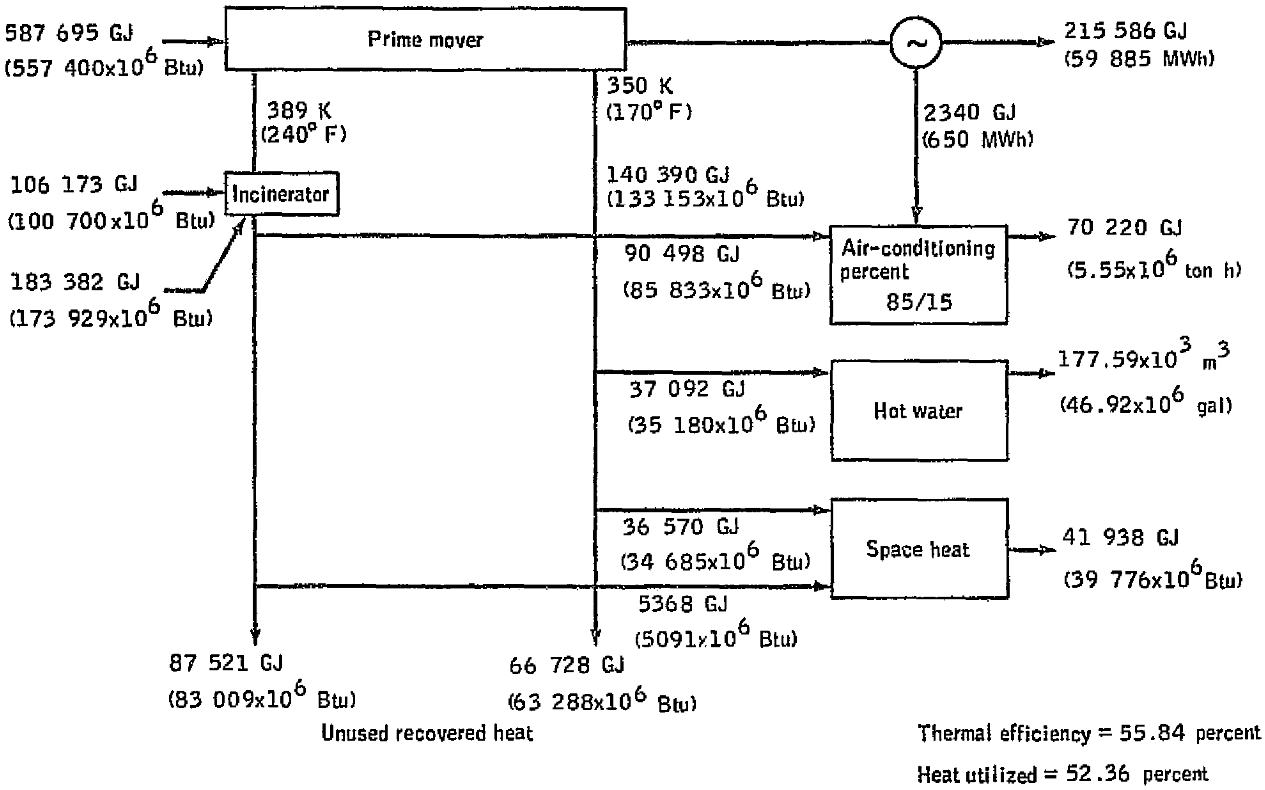


(c) Summer.



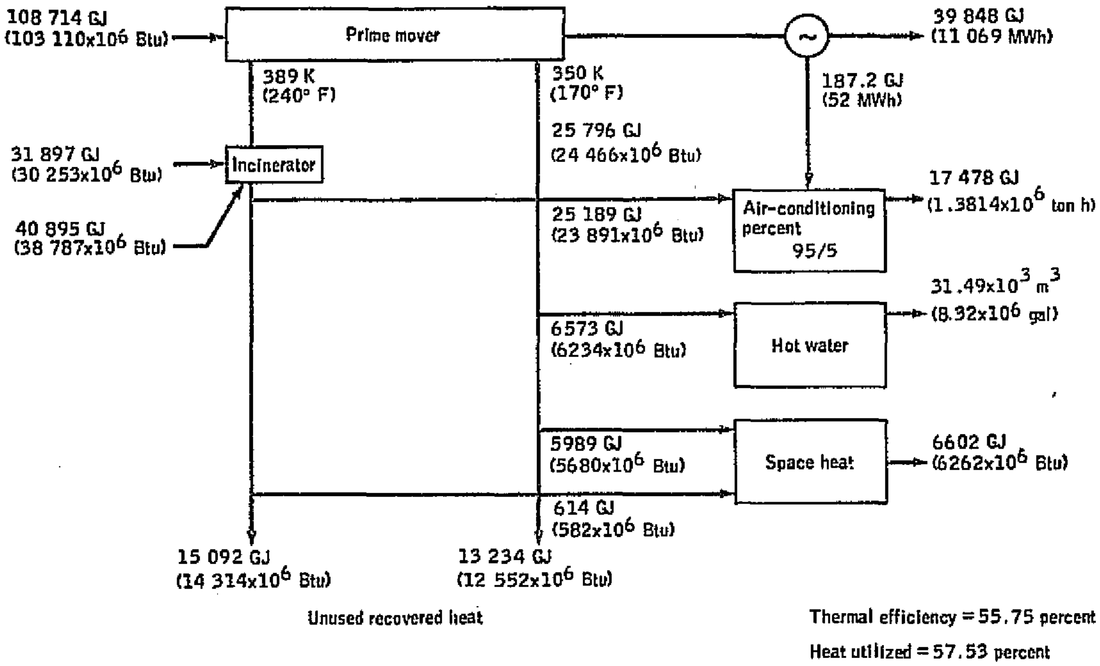
(d) Fall.

Figure C-46.- Continued.

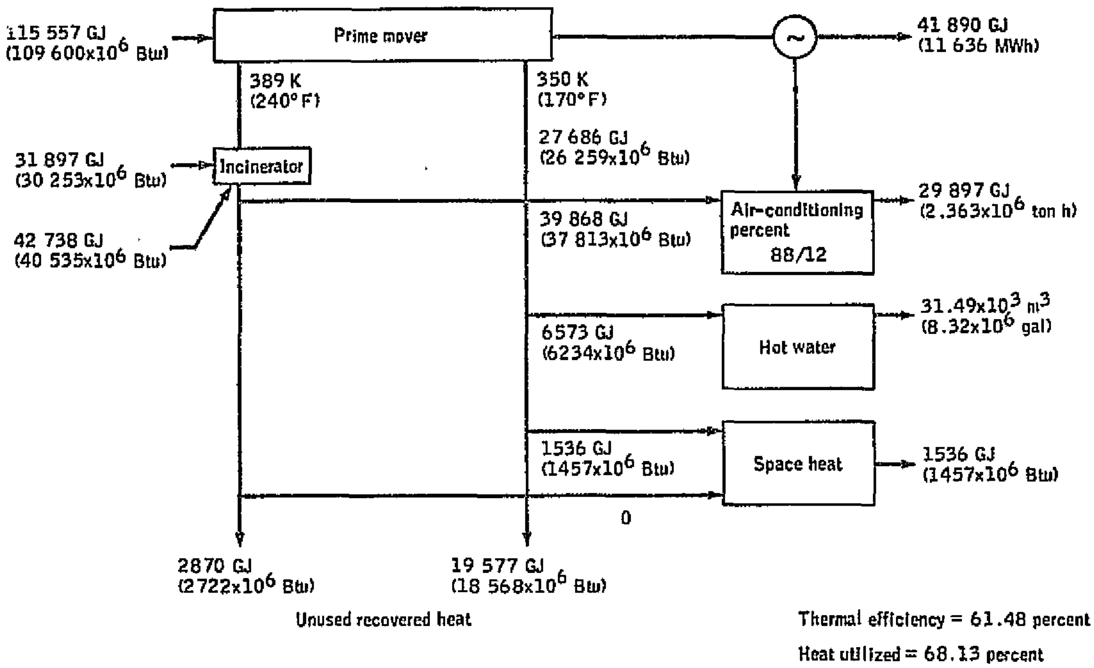


(e) Annual season.

Figure C-46.- Concluded.

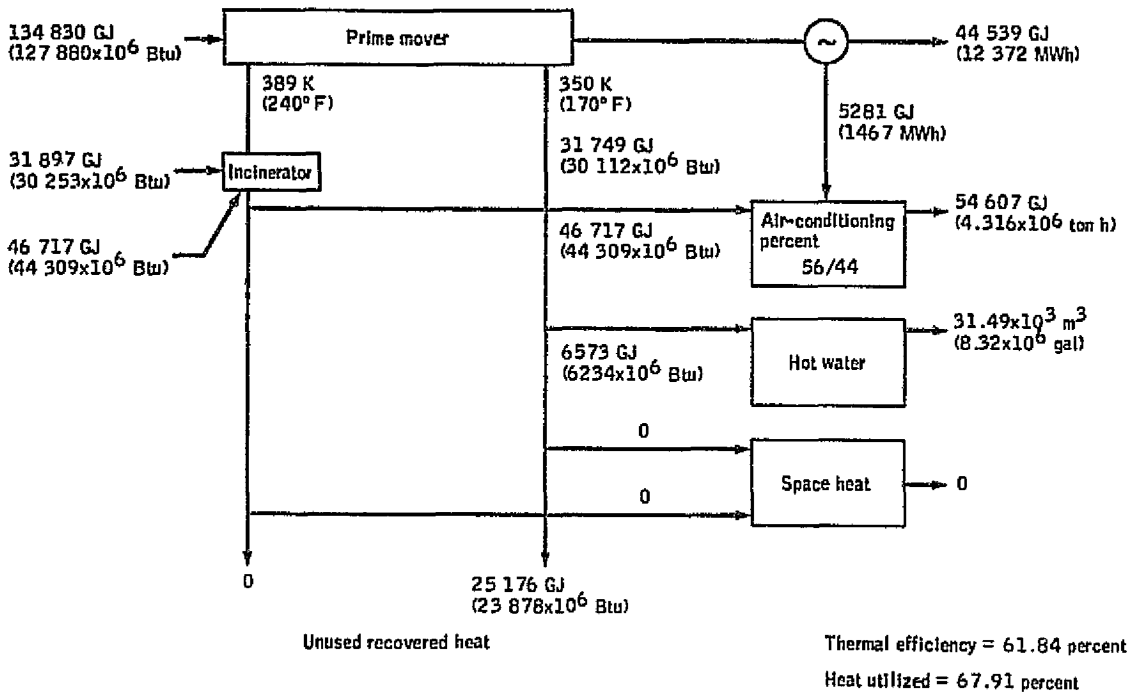


(a) Winter.

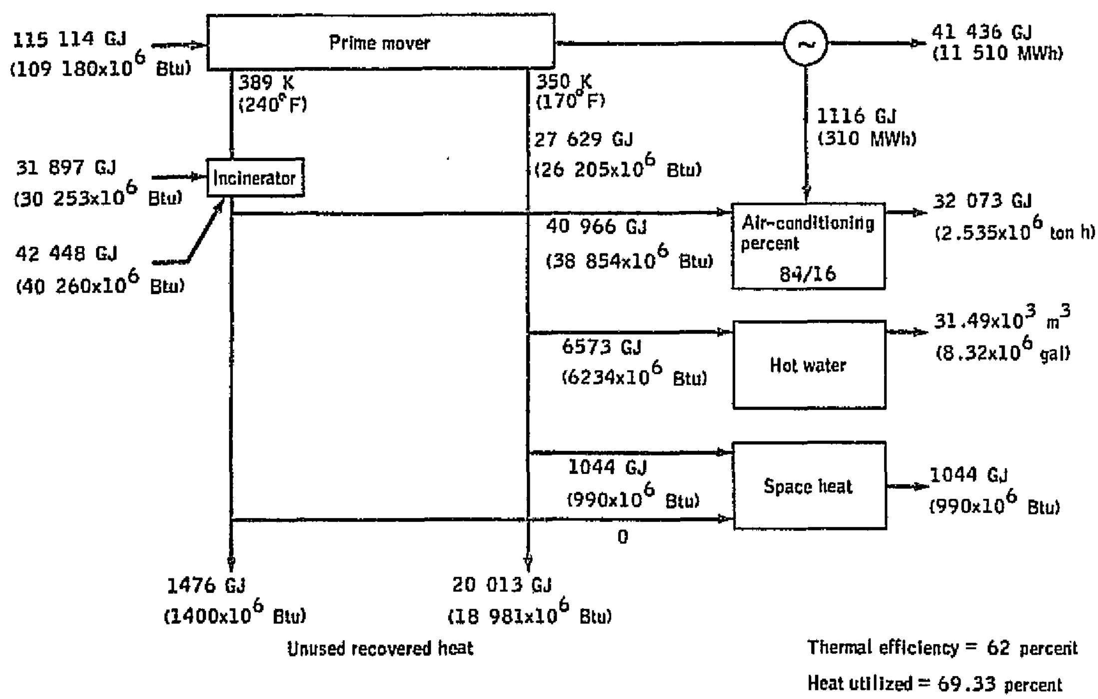


(b) Spring.

Figure C-47.- The CBD phase I energy utilization for the 3rd year of the 5-year development.

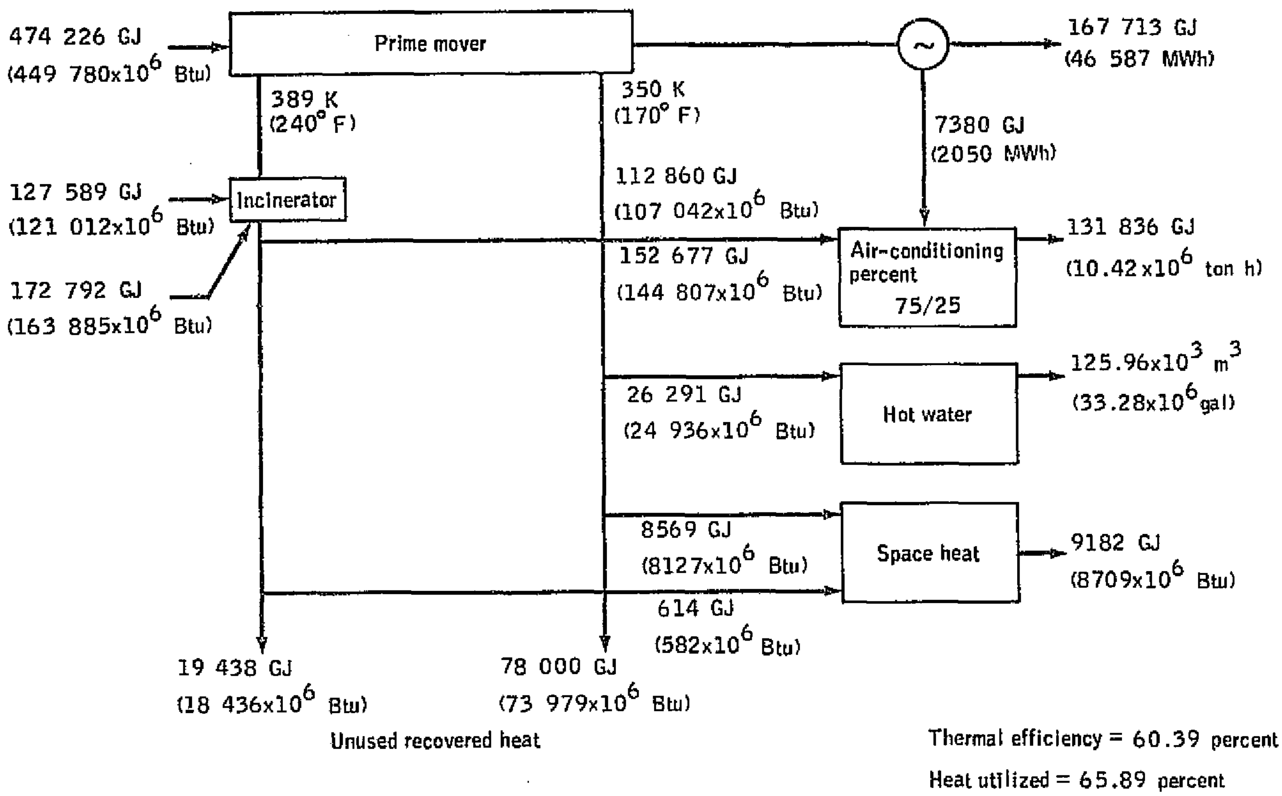


(c) Summer.



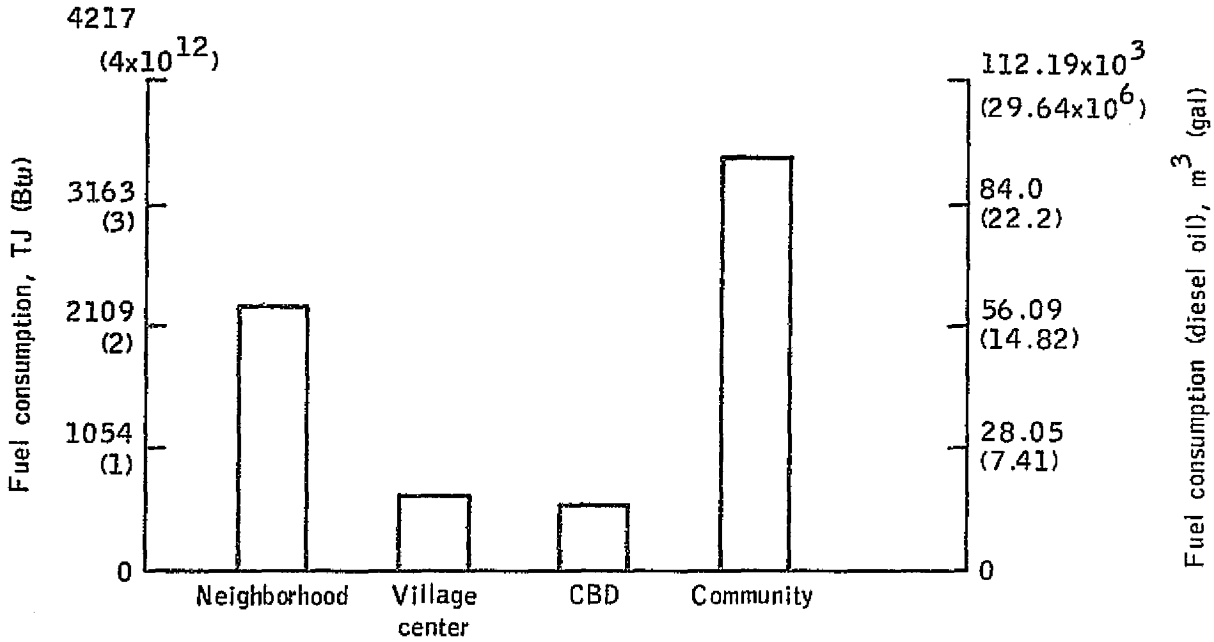
(d) Fall.

Figure C-47.- Continued.

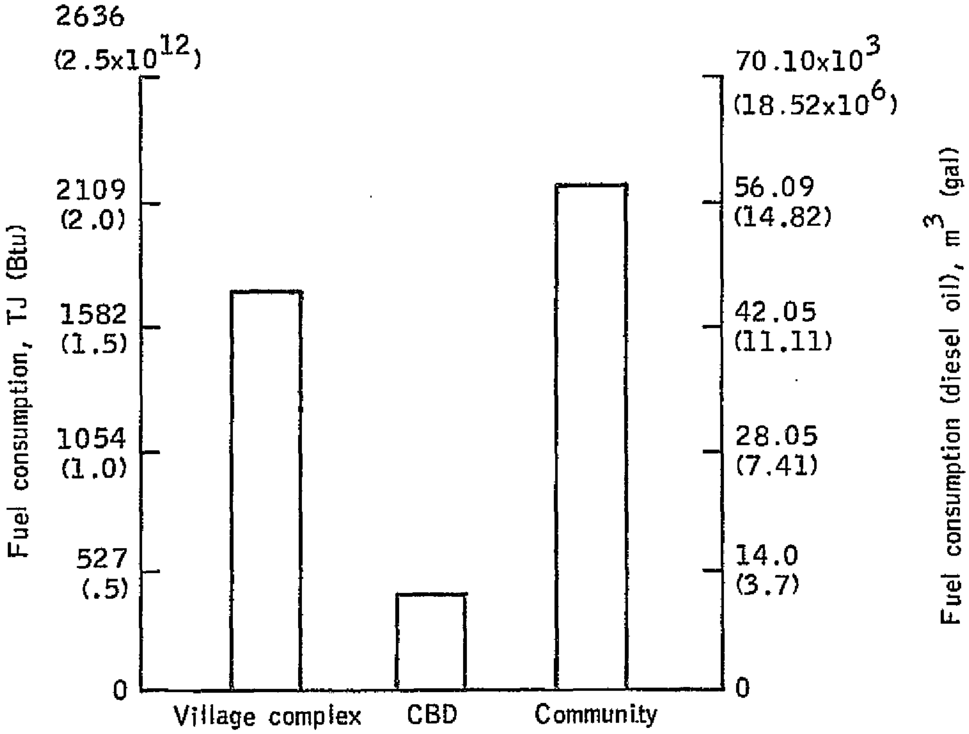


(e) Annual season.

Figure C-47.- Concluded.



(a) Conventional system.



(b) The 8-MIUS option.

Figure C-48.- Annual fuel consumption for a 4-year growth period.

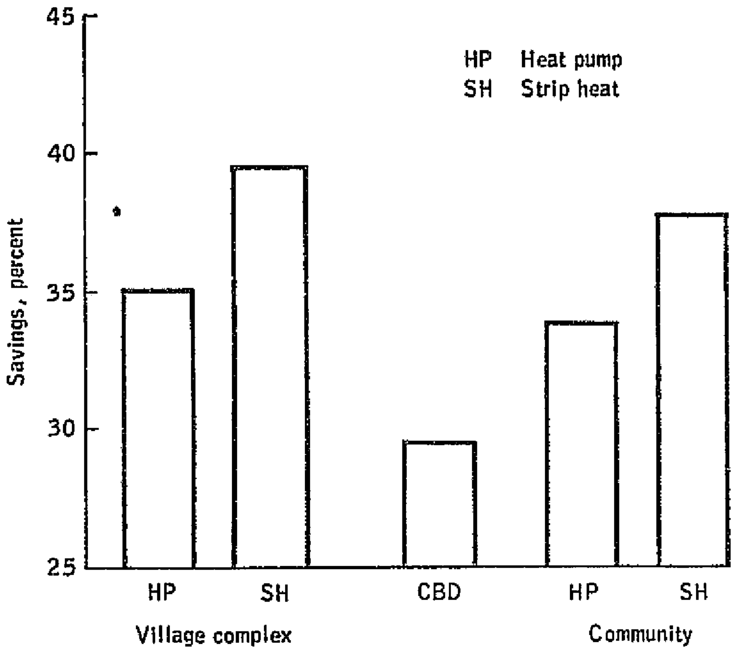


Figure C-49.- Annual fuel savings of the 8-MIUS option at the 4-year point as compared to a conventional system.

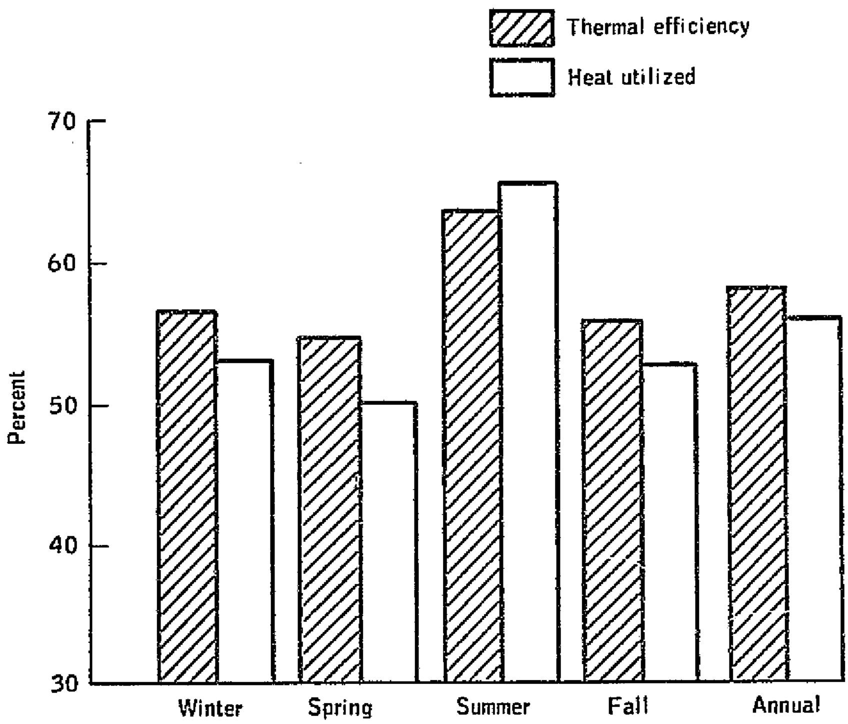


Figure C-50.- Community 8-MIUS thermal efficiency at the 4-year growth point.

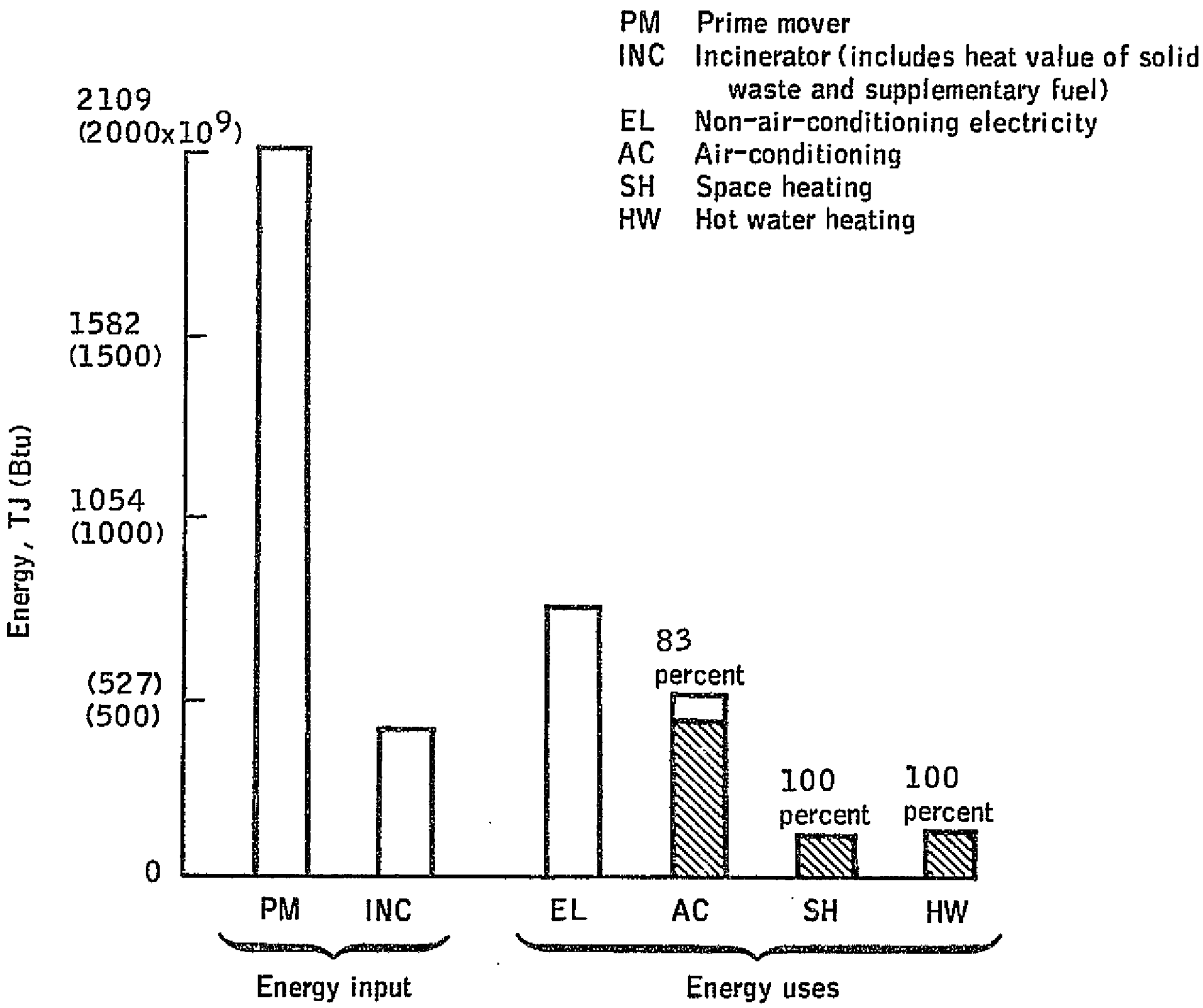
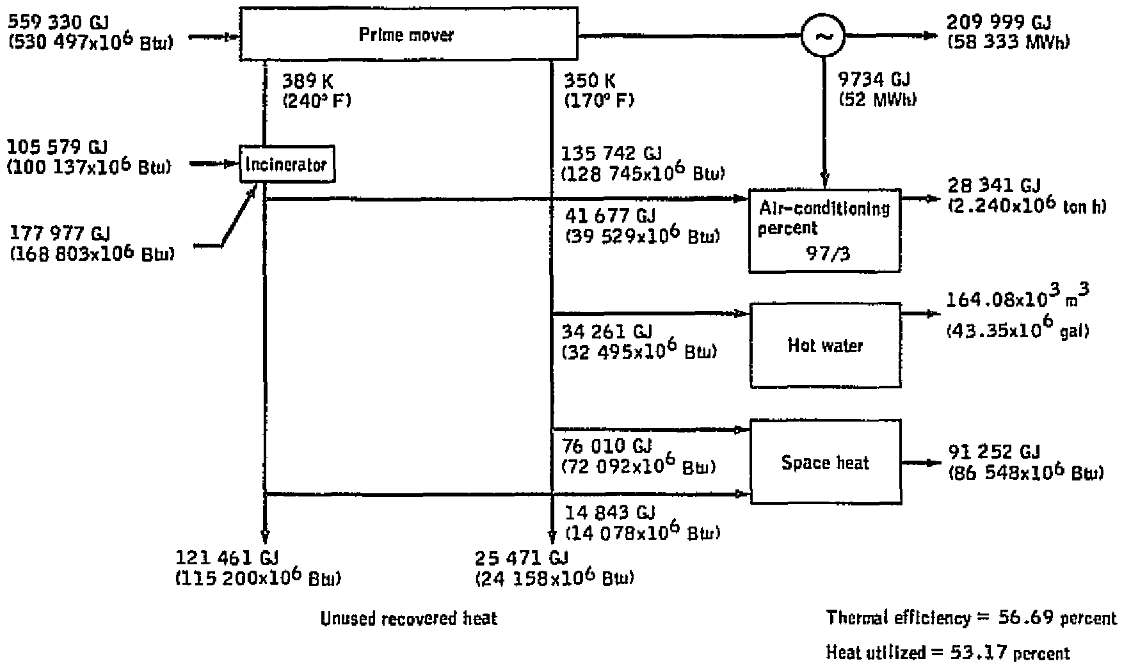
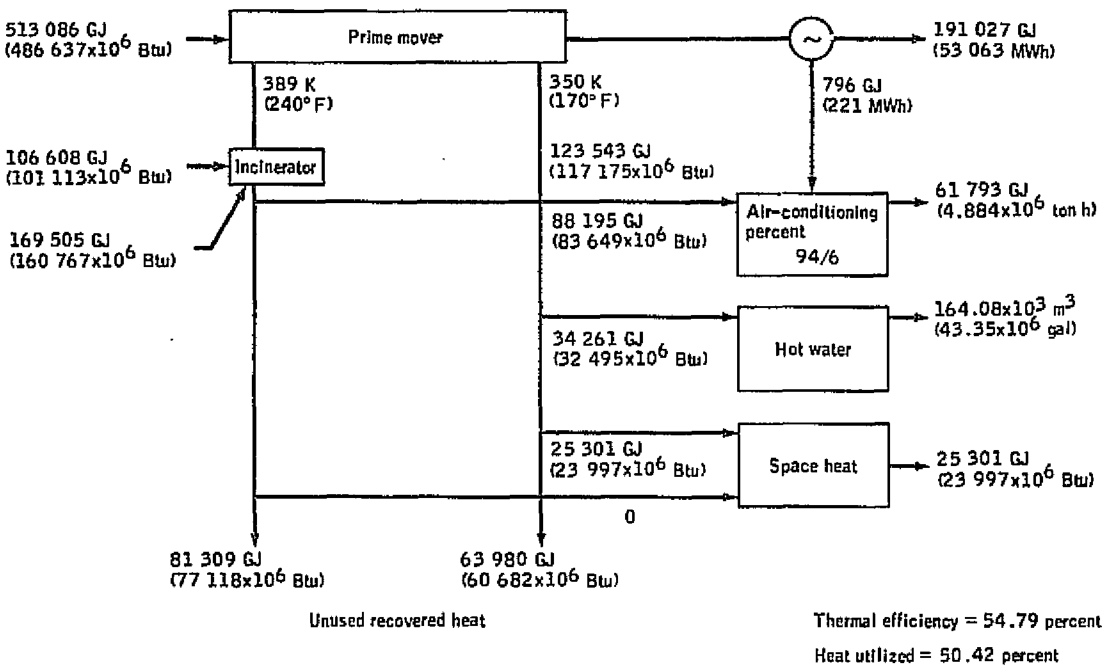


Figure C-51.- Bar chart showing annual energy utilization for the 8-MIUS option at the 4-year growth point.

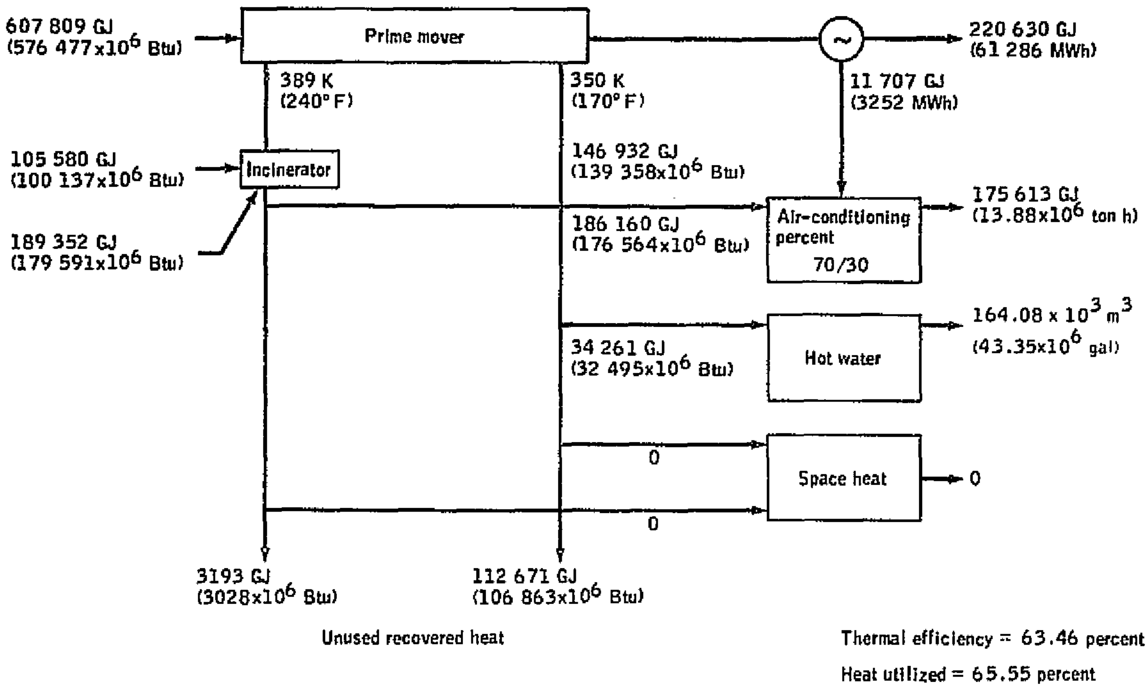


(a) Winter.

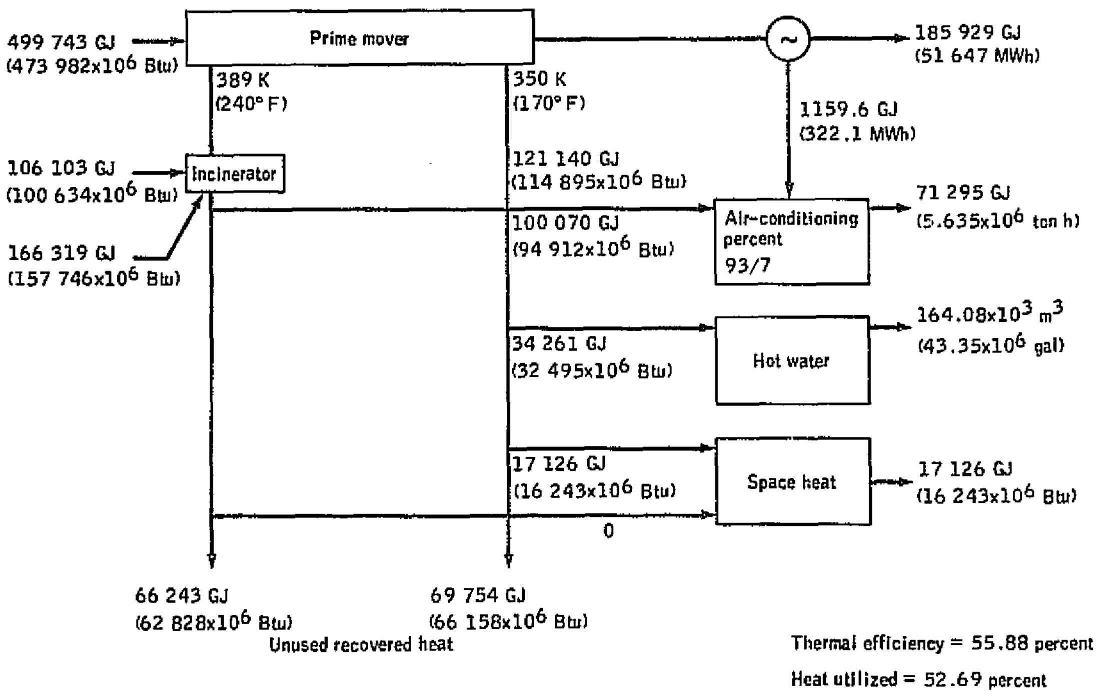


(b) Spring.

Figure C-52.- Community 8-MIUS option energy utilization at the 4-year growth point.

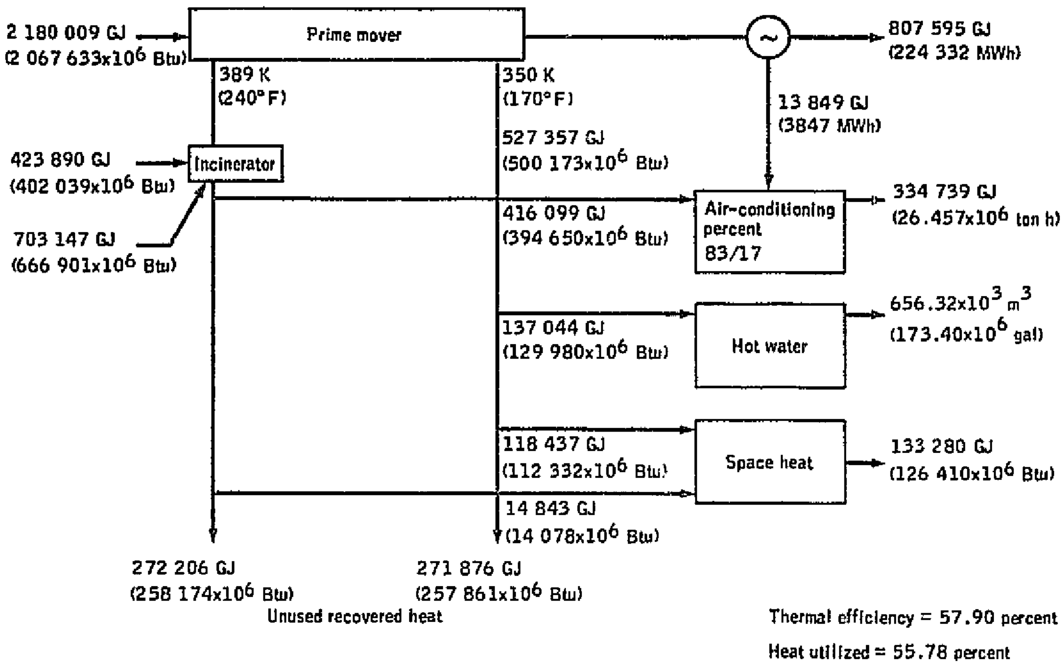


(c) Summer.



(d) Fall.

Figure C-52.- Continued.



(e) Annual season.

Figure C-52.- Concluded.

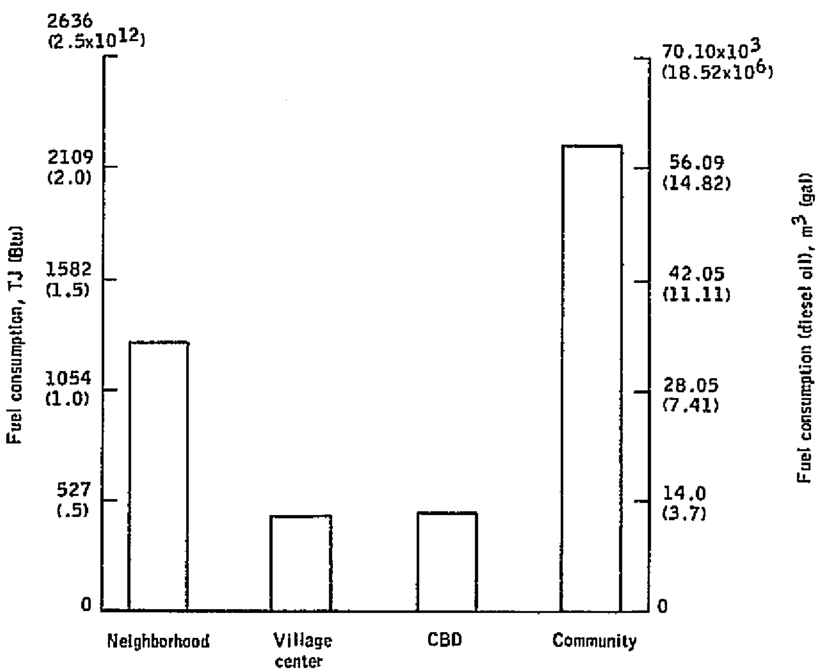


Figure C-53.- Annual fuel consumption for the 29-MIUS option at the 4-year growth point.

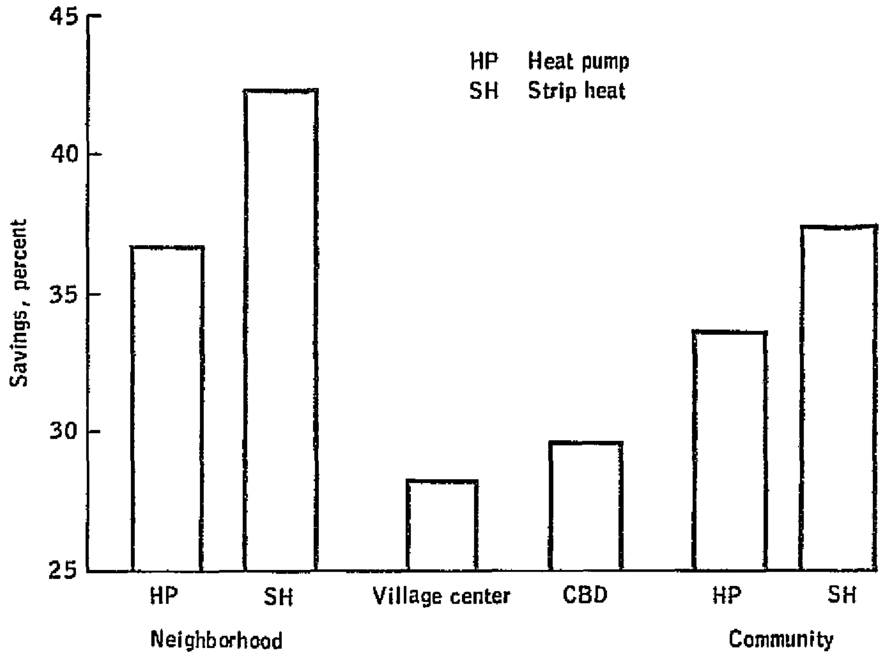


Figure C-54.- Annual fuel savings of the 29-MIUS option at the 4-year growth point as compared to a conventional system.

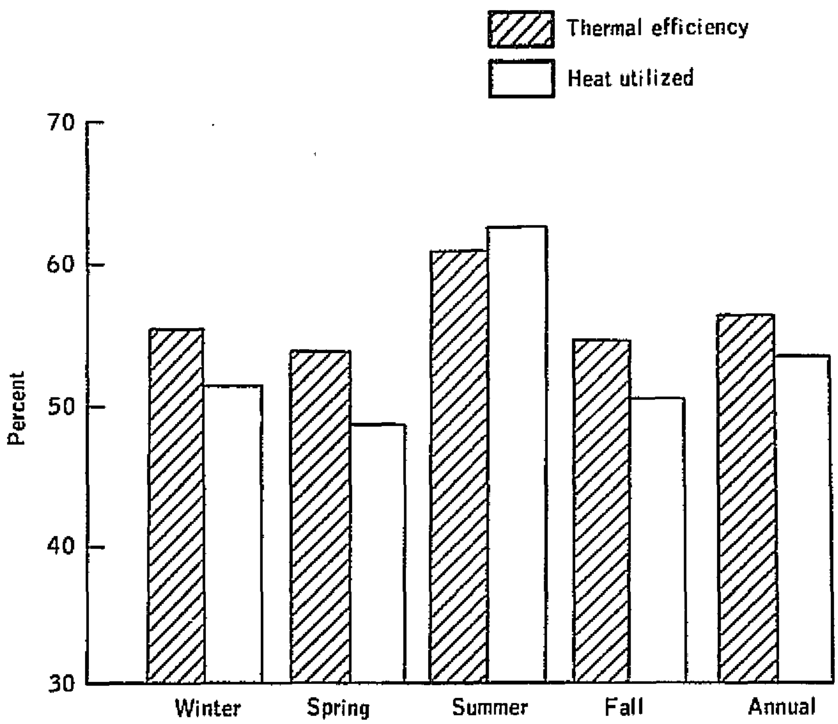


Figure C-55.- Community 29-MIUS option thermal efficiency at the 4-year growth point.

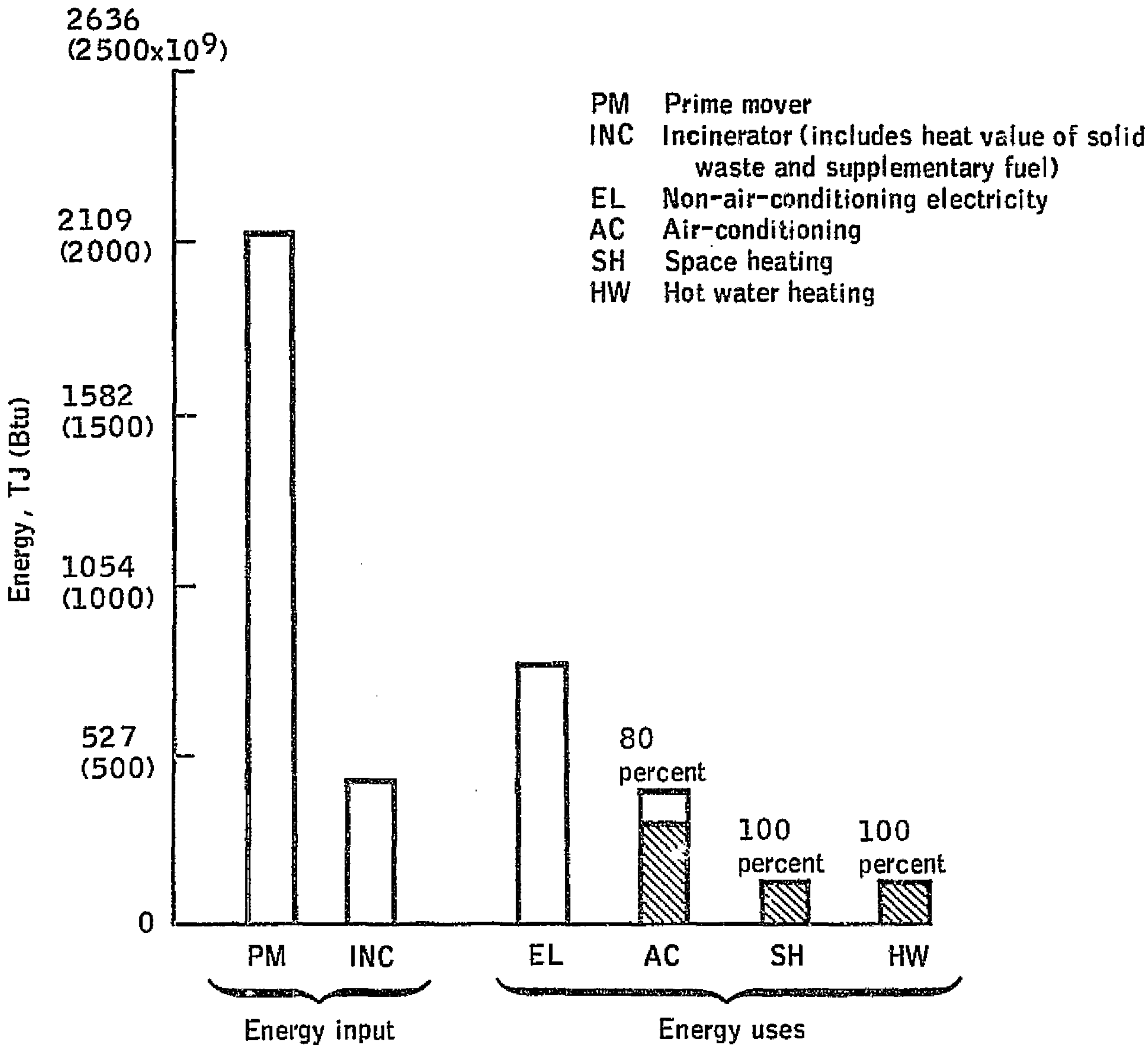
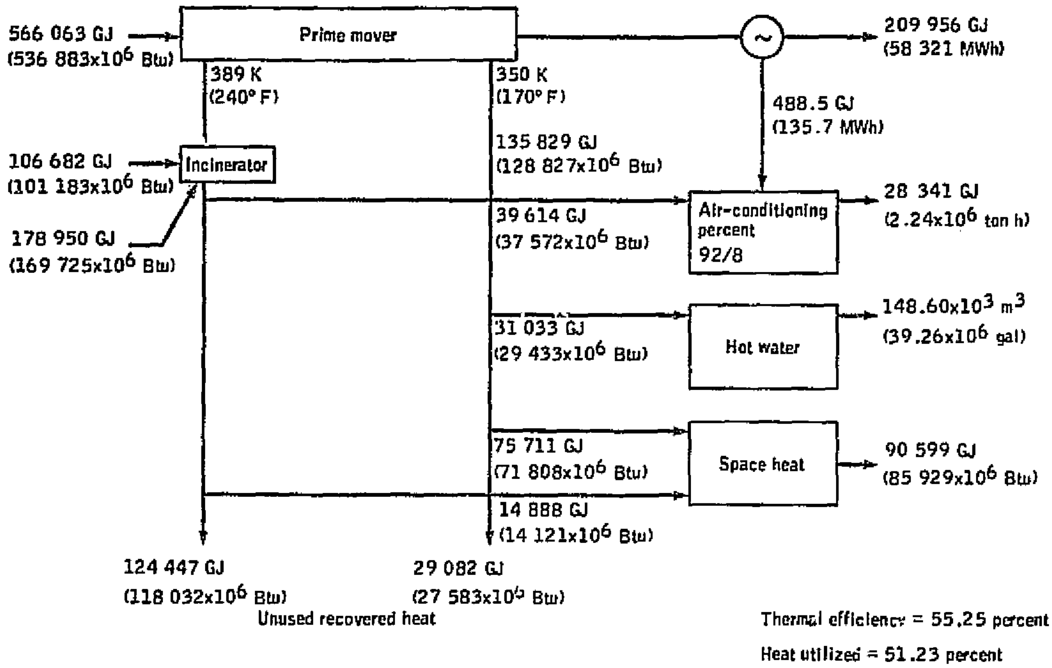
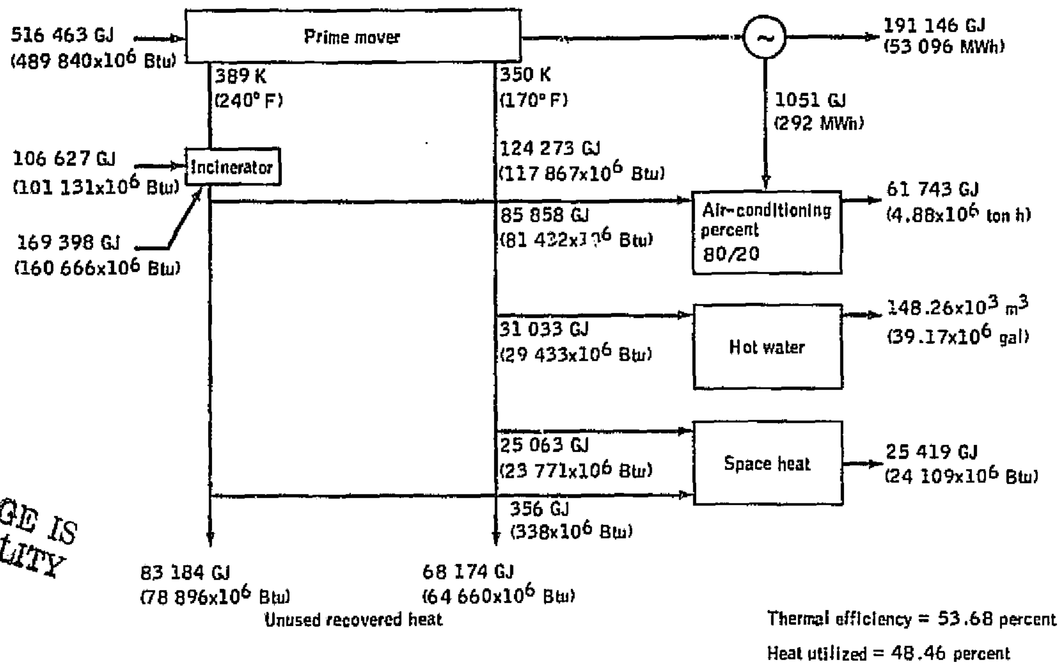


Figure C-56.- Bar chart showing annual energy utilization for the 29-MIUS option at the 4-year growth point.

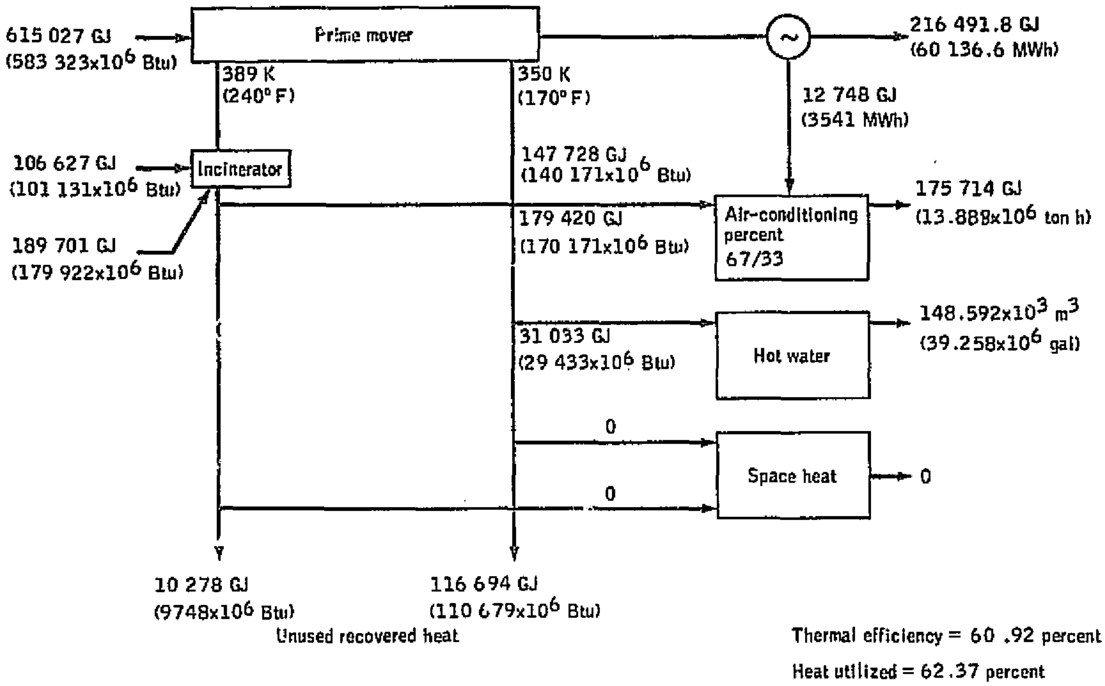


(a) Winter.

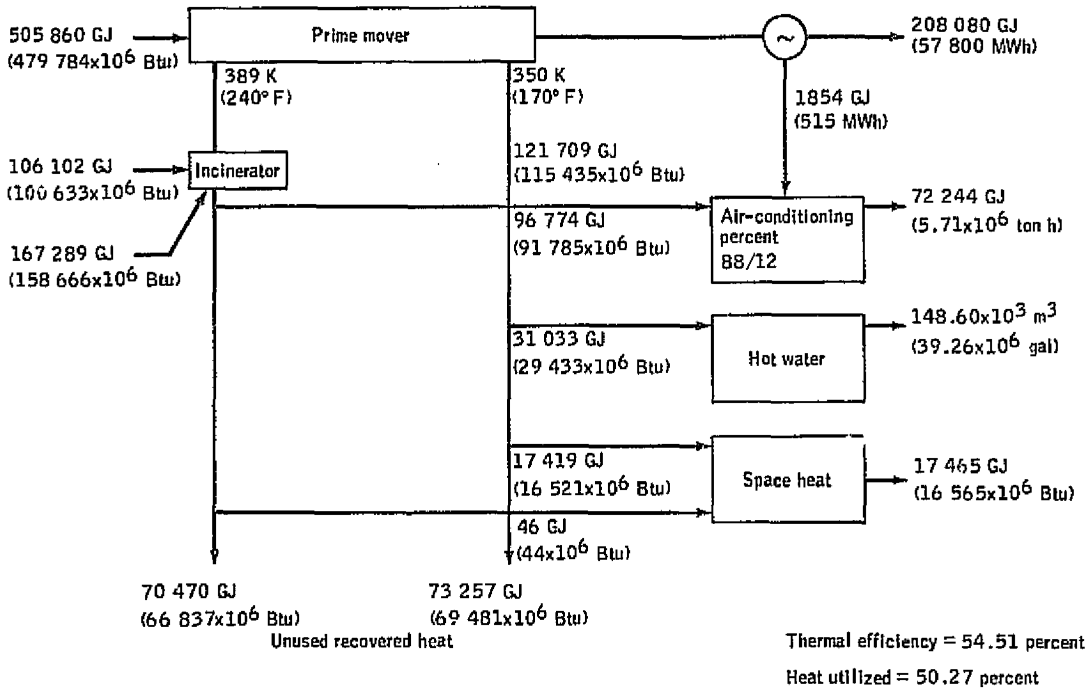


(b) Spring.

Figure C-57.- The 29-MIUS option community energy utilization at the 4-year growth point.

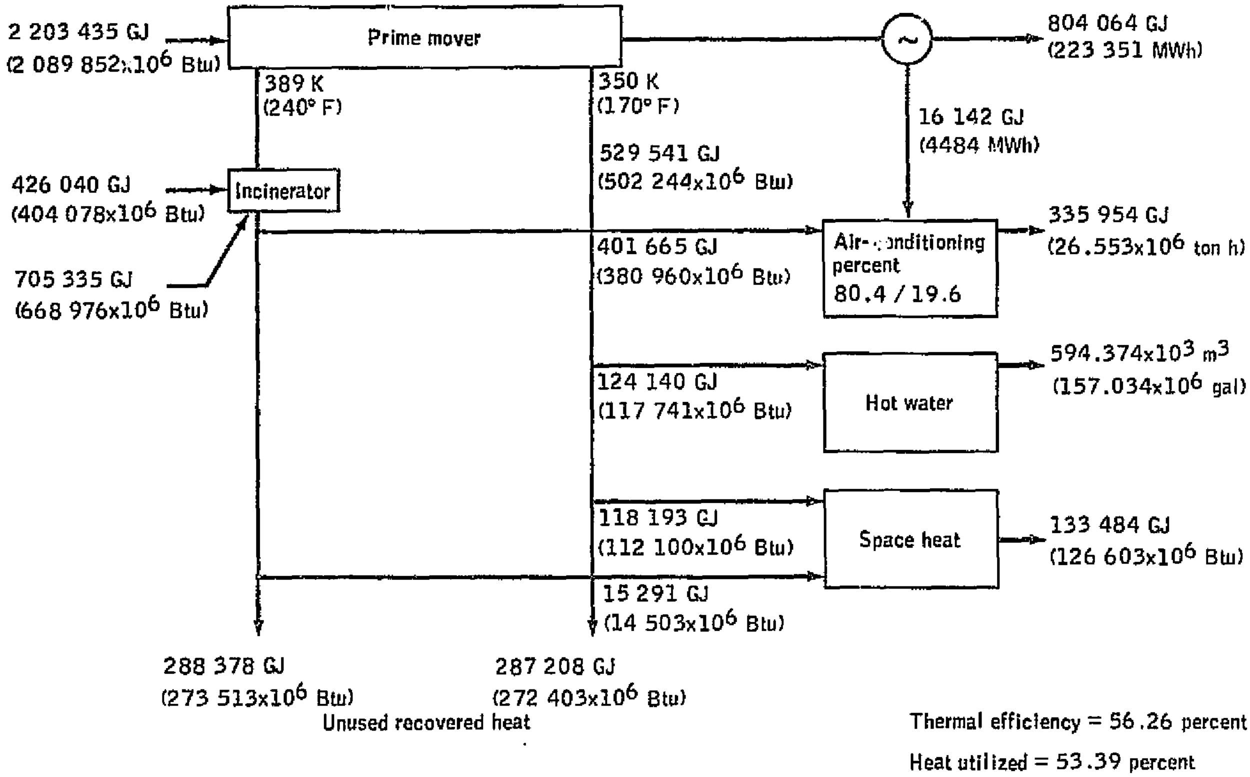


(c) Summer.



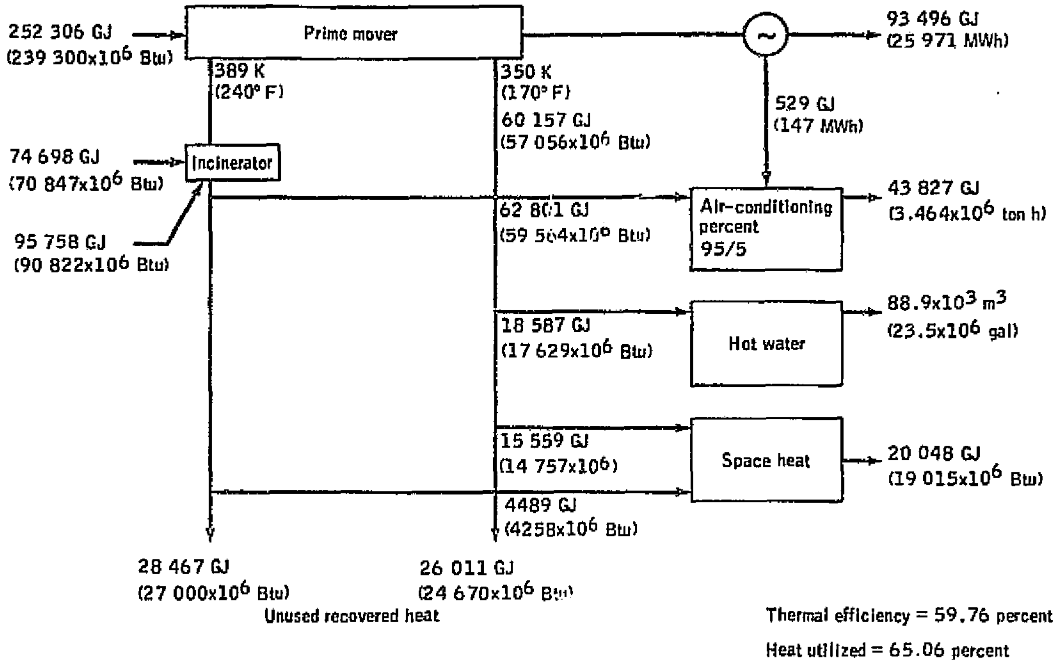
(d) Fall.

Figure C-57.- Continued.

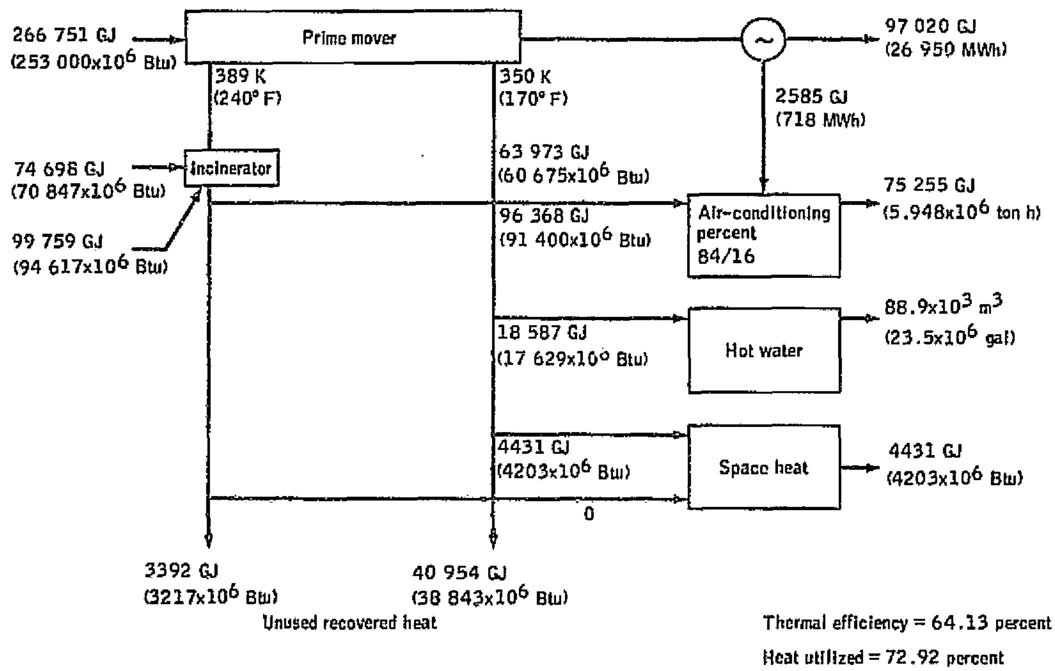


(e) Annual season.

Figure C-57.- Concluded.

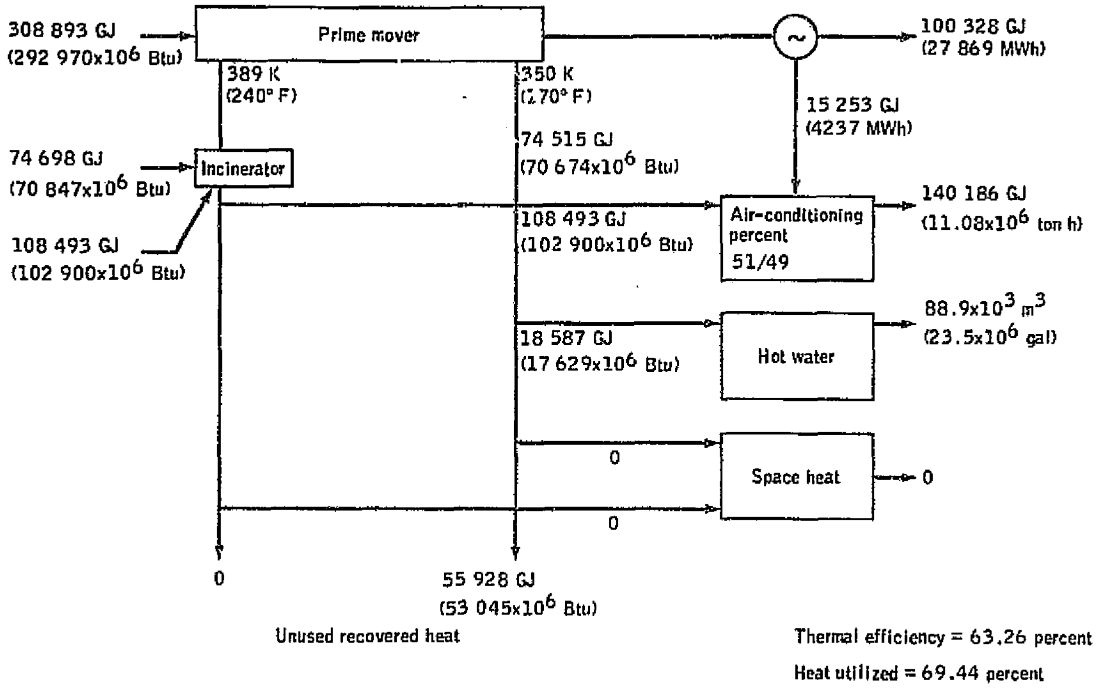


(a) Winter.

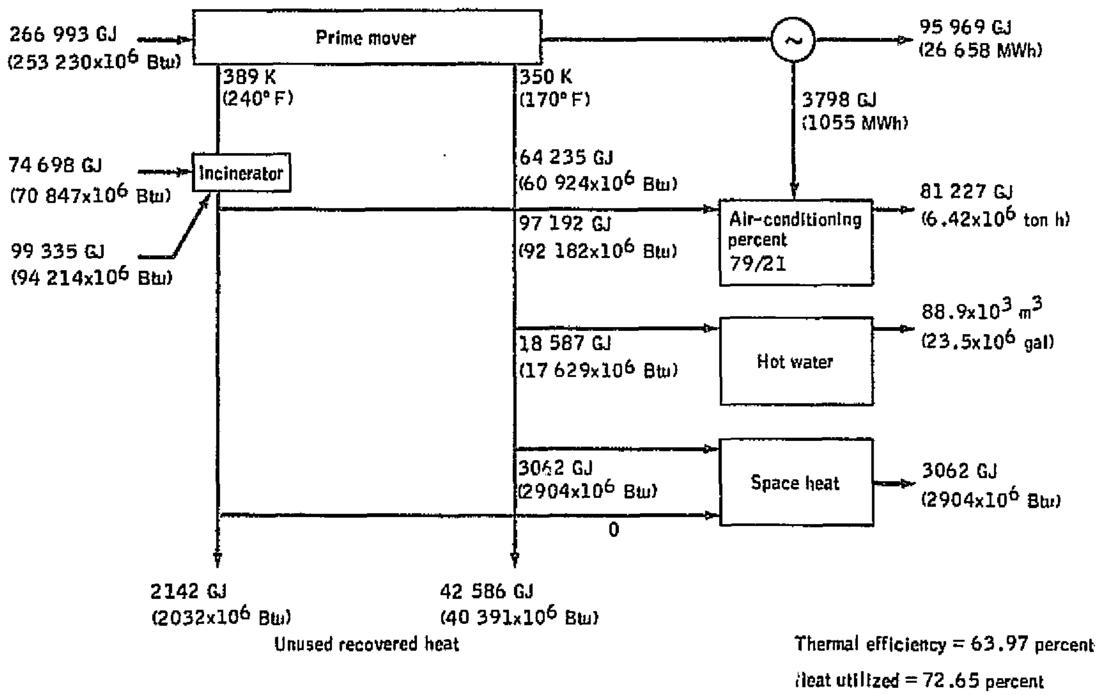


(b) Spring.

Figure C-58.- Energy utilization for the CBD at the 10-year growth point.

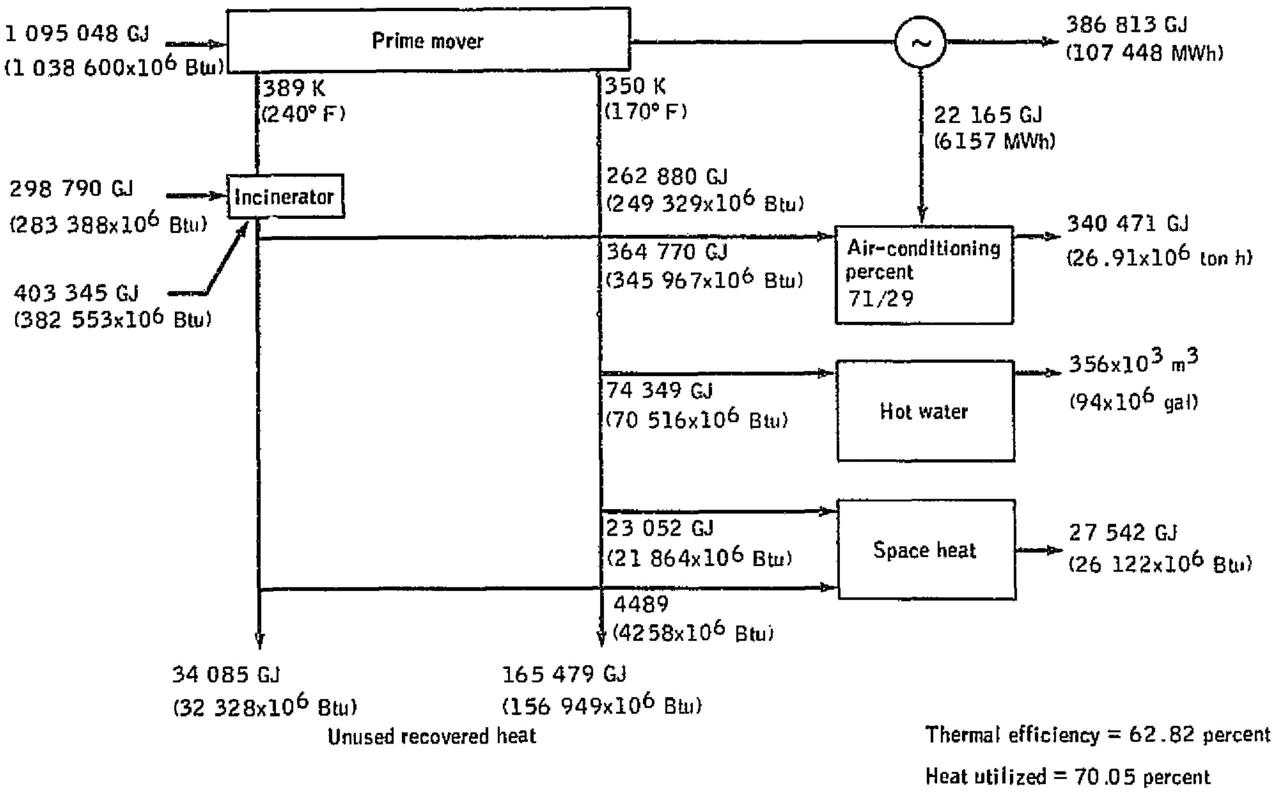


(c) Summer.



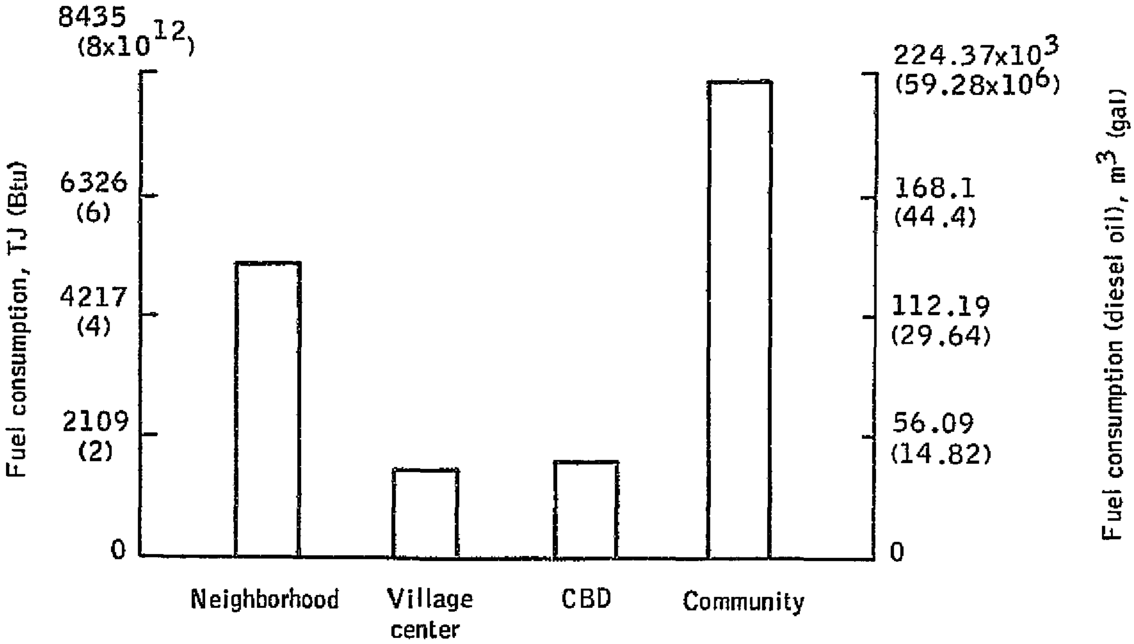
(d) Fall.

Figure C-58.- Continued.

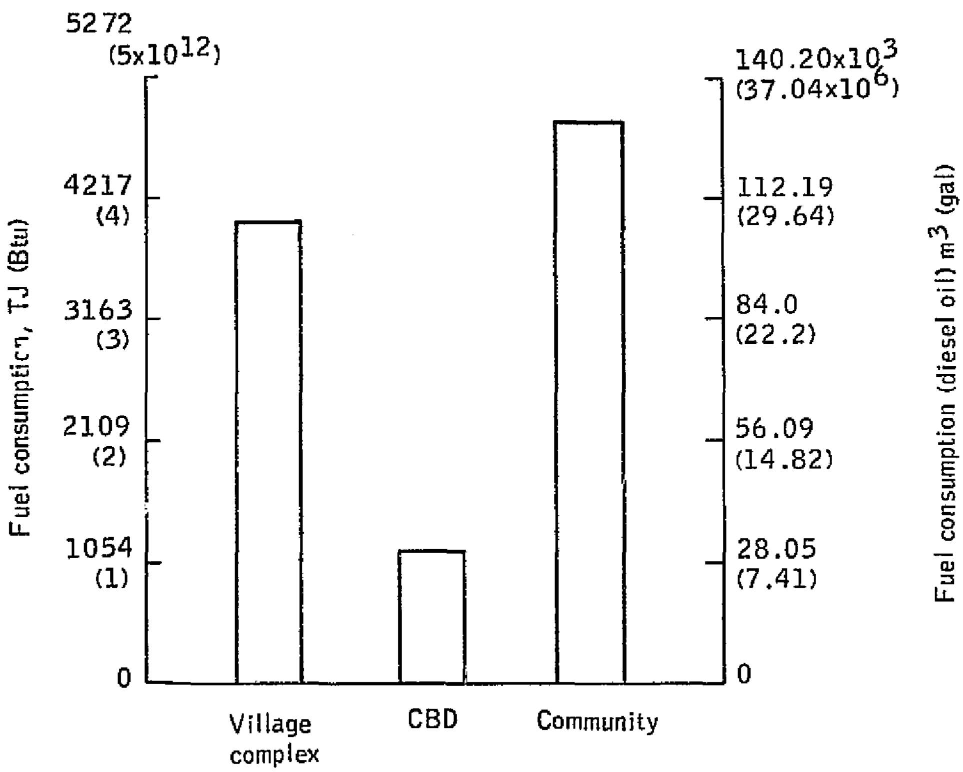


(e) Annual season.

Figure C-58.- Concluded.



(a) Conventional system.



(b) The 8-MIUS option.

Figure C-59.- Annual fuel consumption at the 10-year growth point.

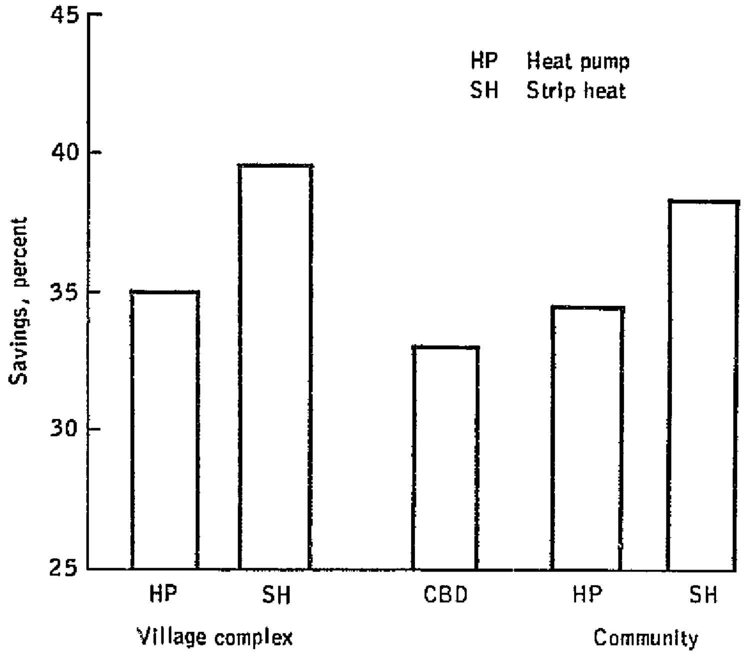


Figure C-60.- Annual fuel savings of the 8-MIUS option at the 10-year growth point as compared to a conventional system.

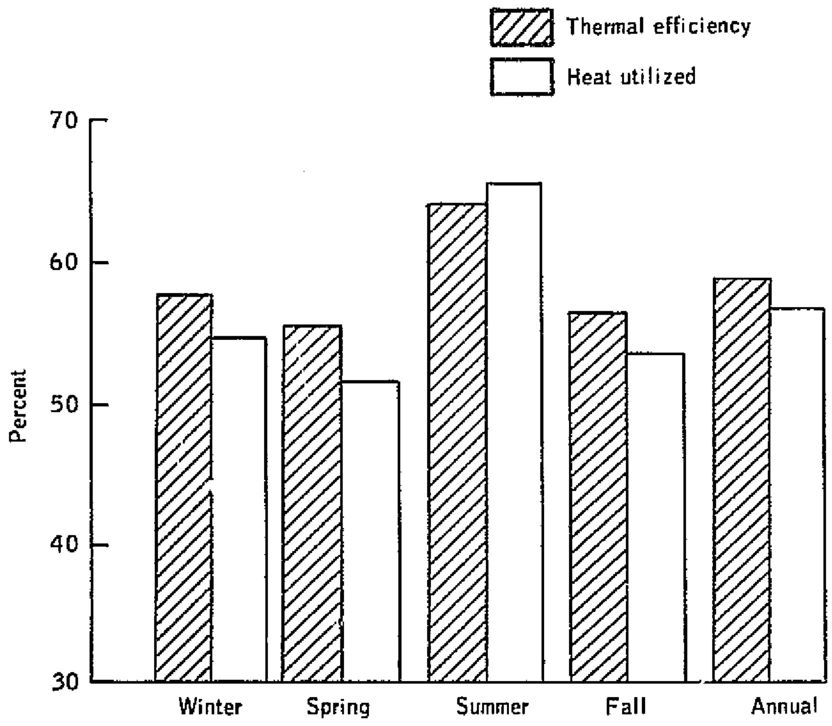


Figure C-61.- Community 8-MIUS option thermal efficiency at the 10-year growth point.

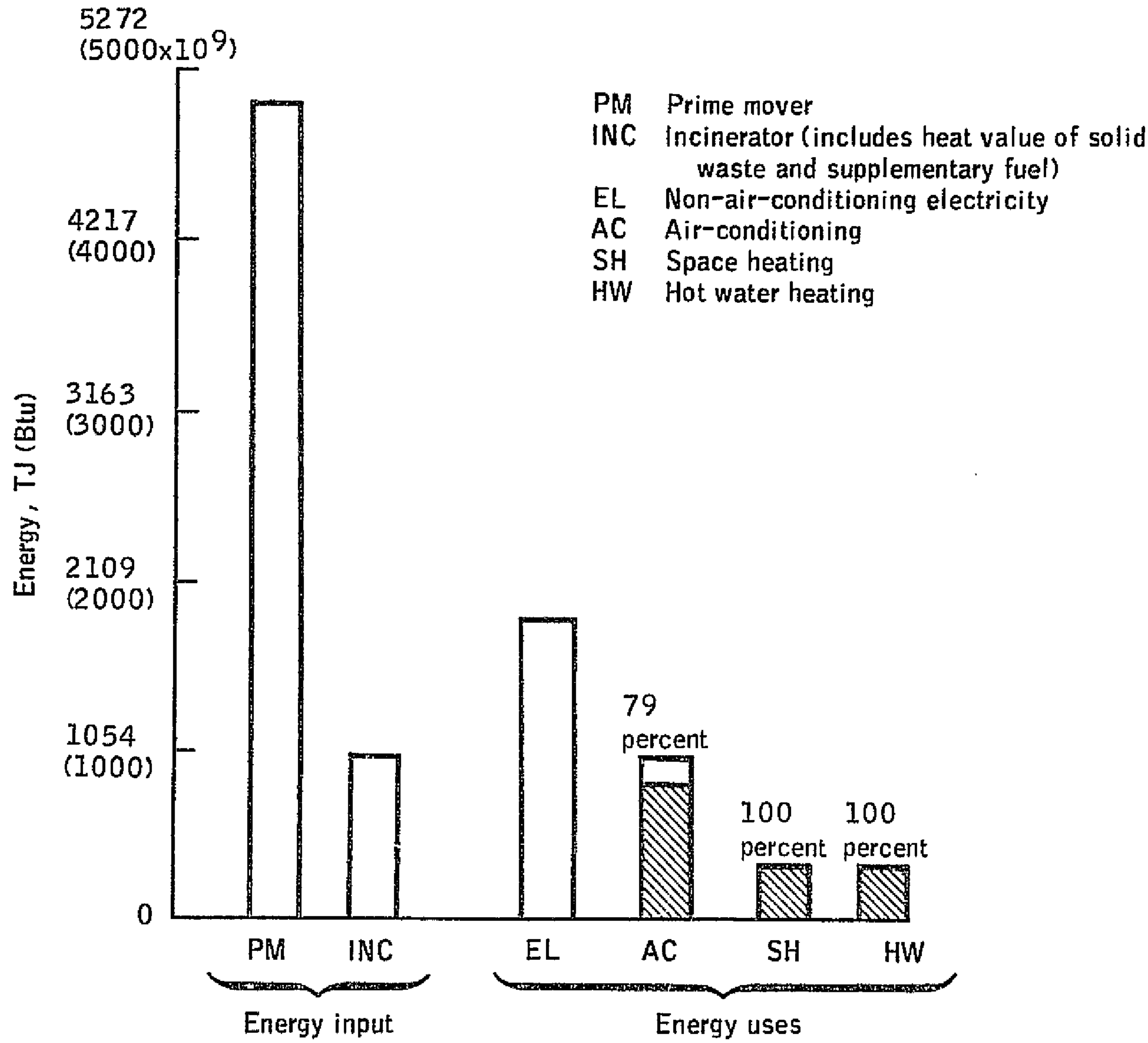
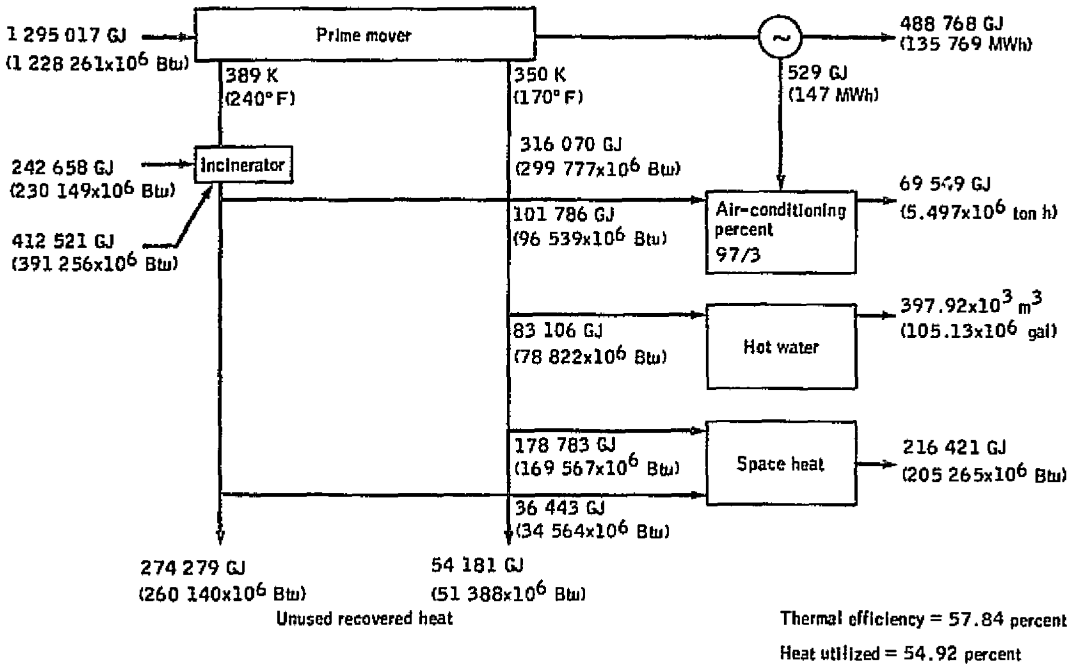
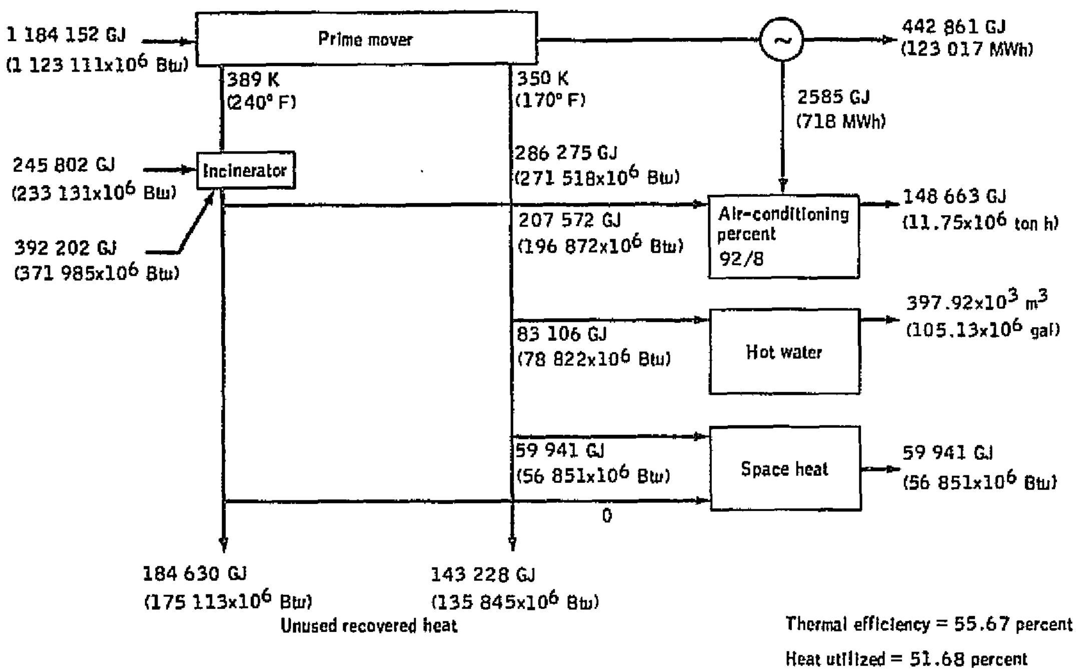


Figure C-62.- Bar chart showing annual energy utilization for the 8-MIUS option at the 10-year growth point.



(a) Winter.



(b) Spring.

Figure C-63.- The 8-MIUS option community energy utilization at the 10-year growth point.

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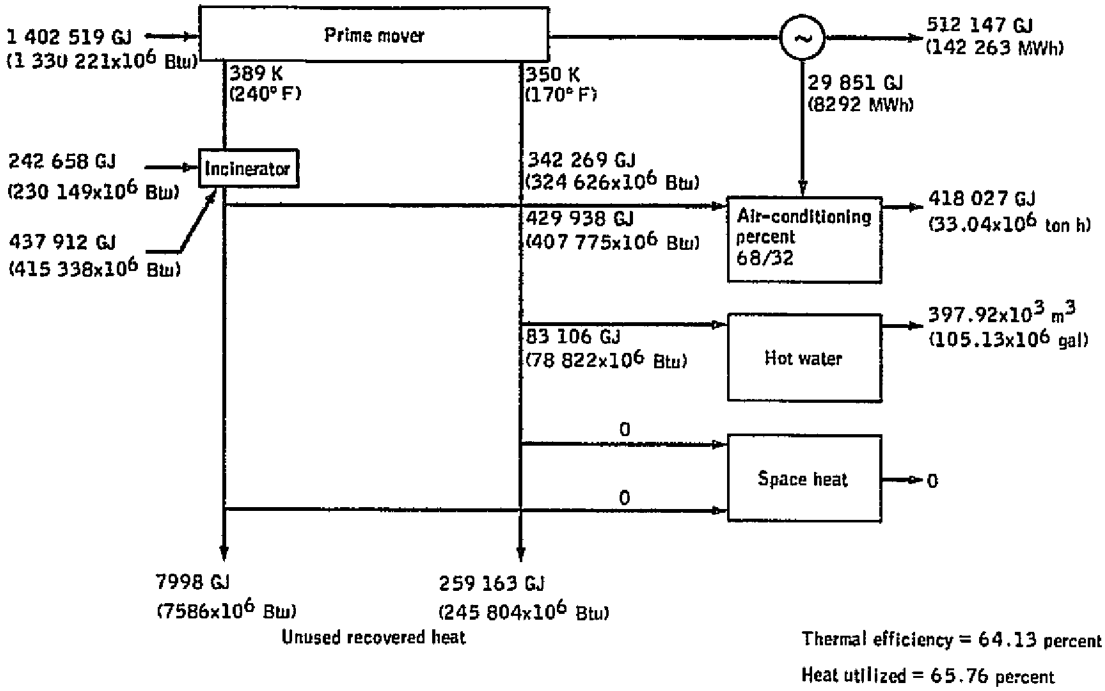
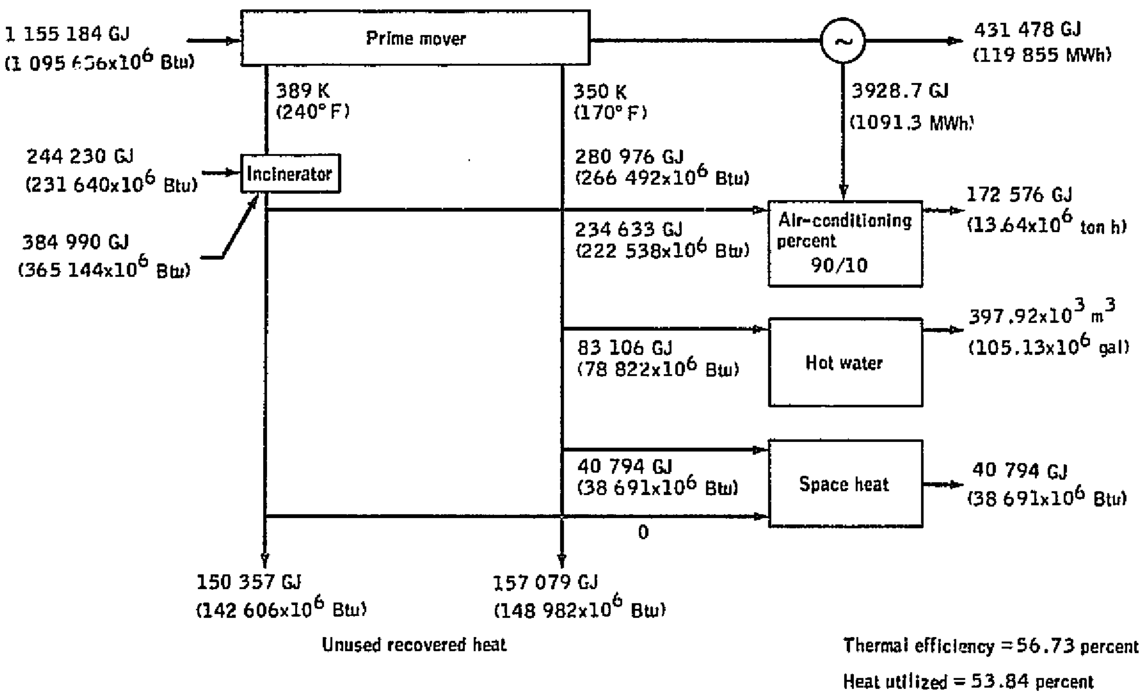
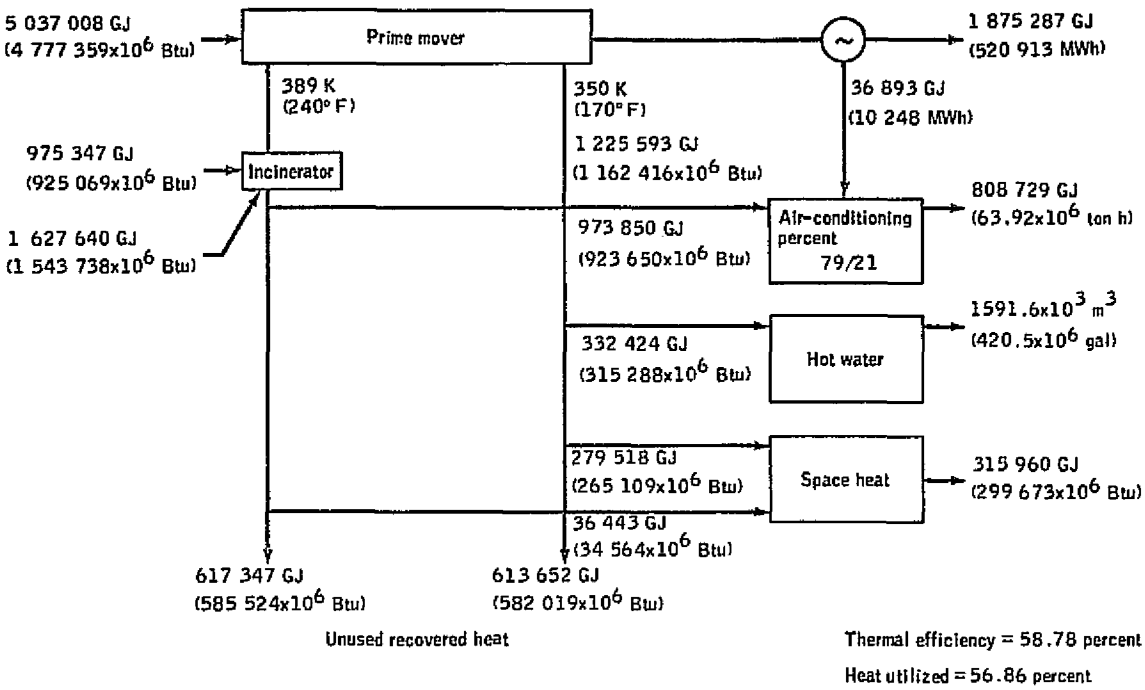


(c) Summer.



(d) Fall.

Figure C-63.- Continued.



(e) Annual season.

Figure C-63.- Concluded.

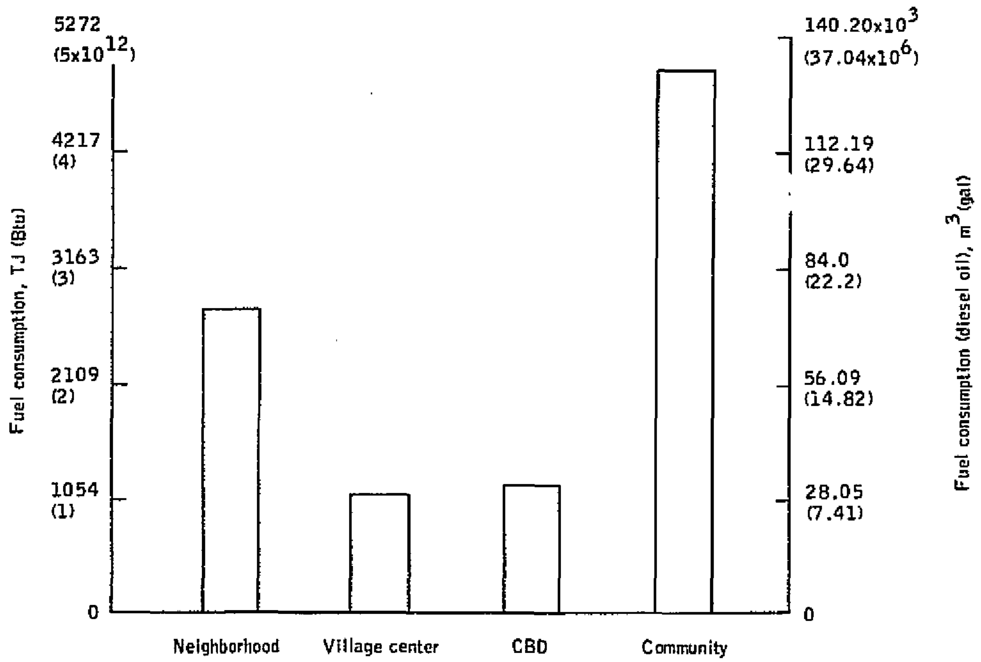


Figure C-64.- Annual fuel consumption for the 29-MIUS option at the 10-year growth point.

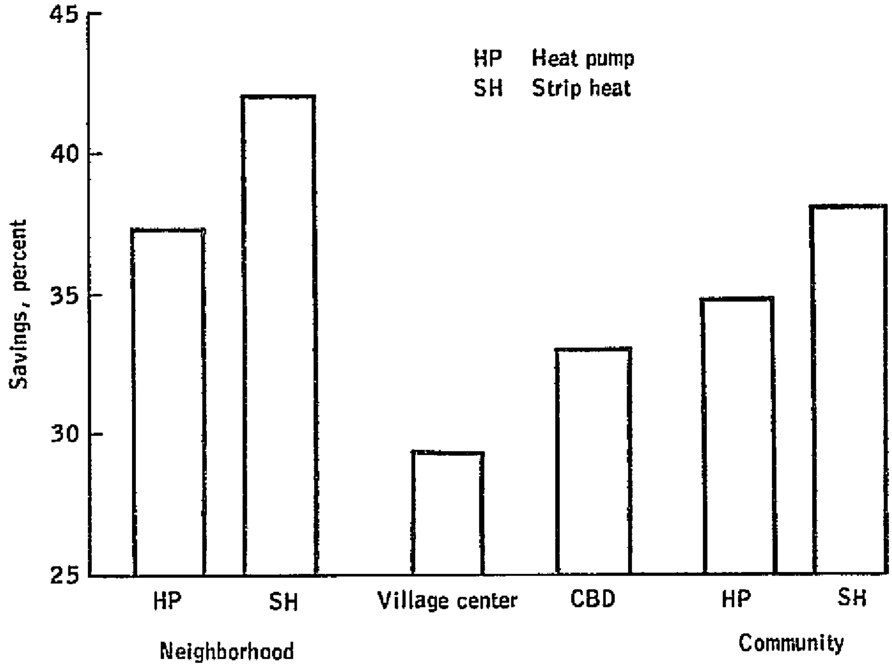


Figure C-65.- Annual fuel savings of the 29-MIUS option at the 10-year growth point as compared to a conventional system.

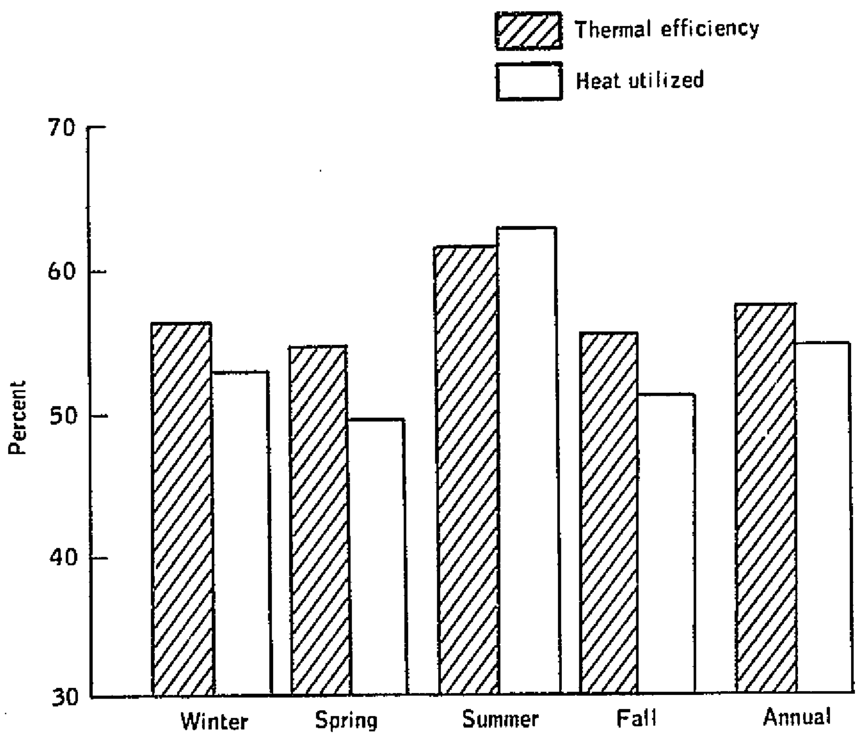


Figure C-66.- Community 29-MIUS option thermal efficiency at the 10-year growth point.

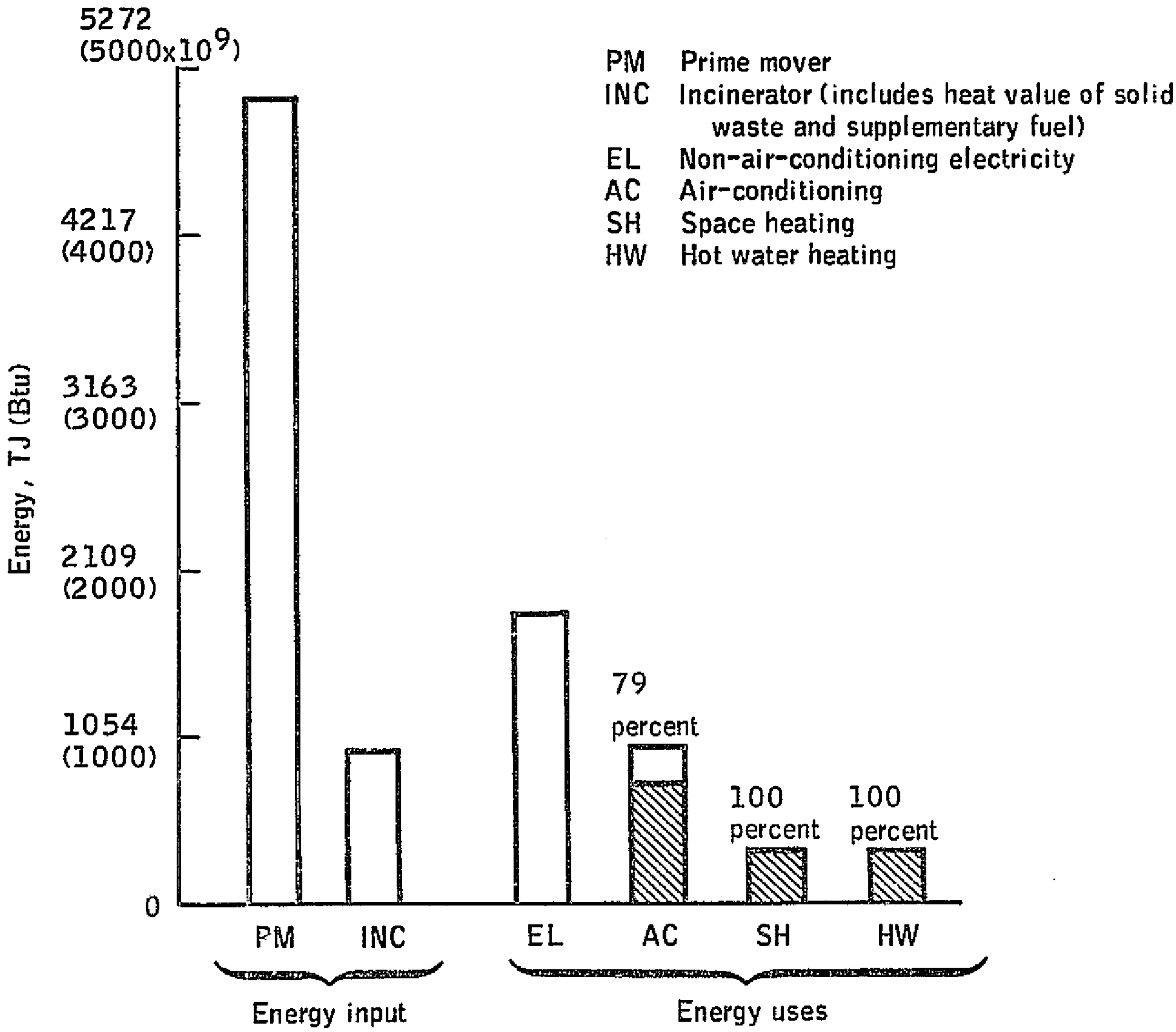
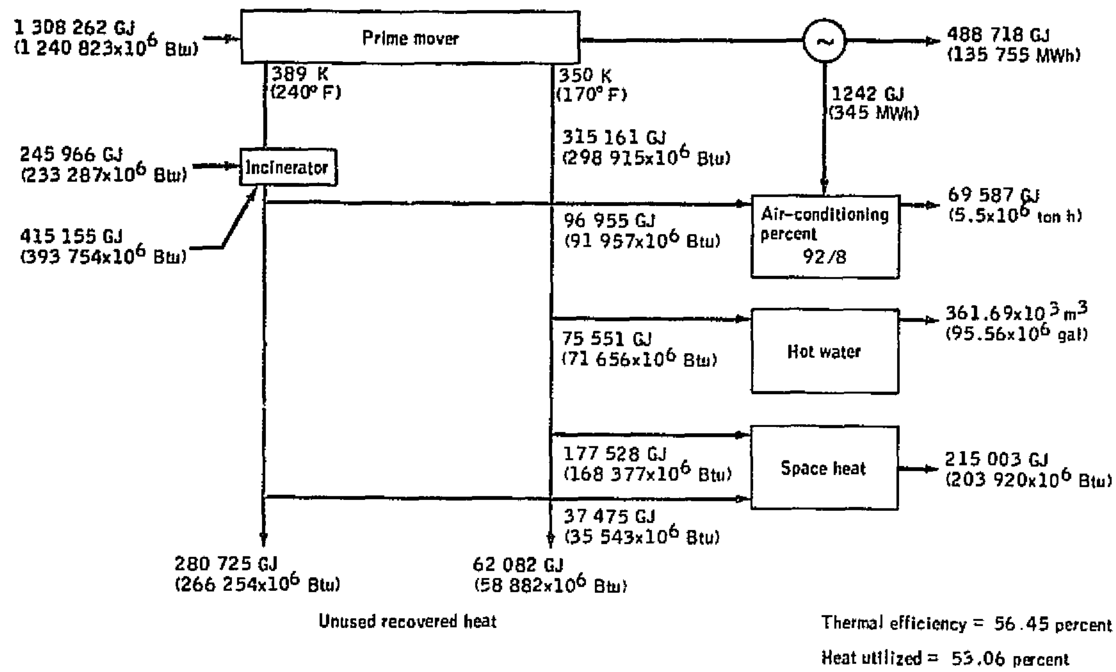
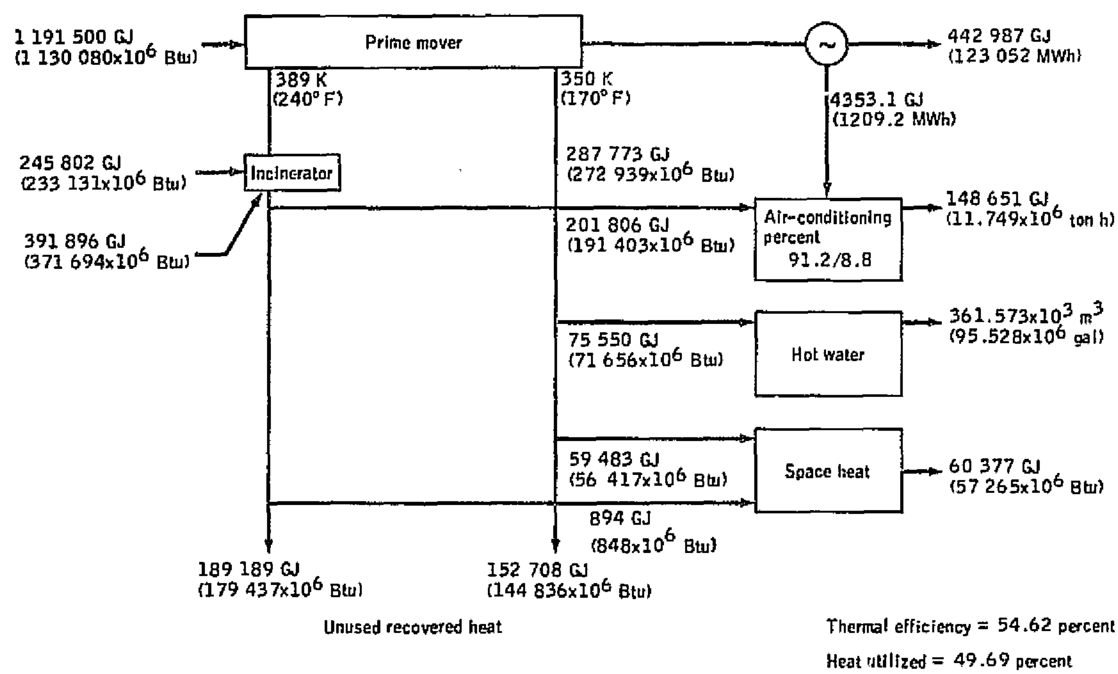


Figure C-67.- Bar chart showing annual energy utilization for the 29-MIUS option at the 10-year growth point.



(a) Winter.



(b) Spring.

Figure C-68.- The 29-MIUS option community energy utilization at the 10-year growth point.

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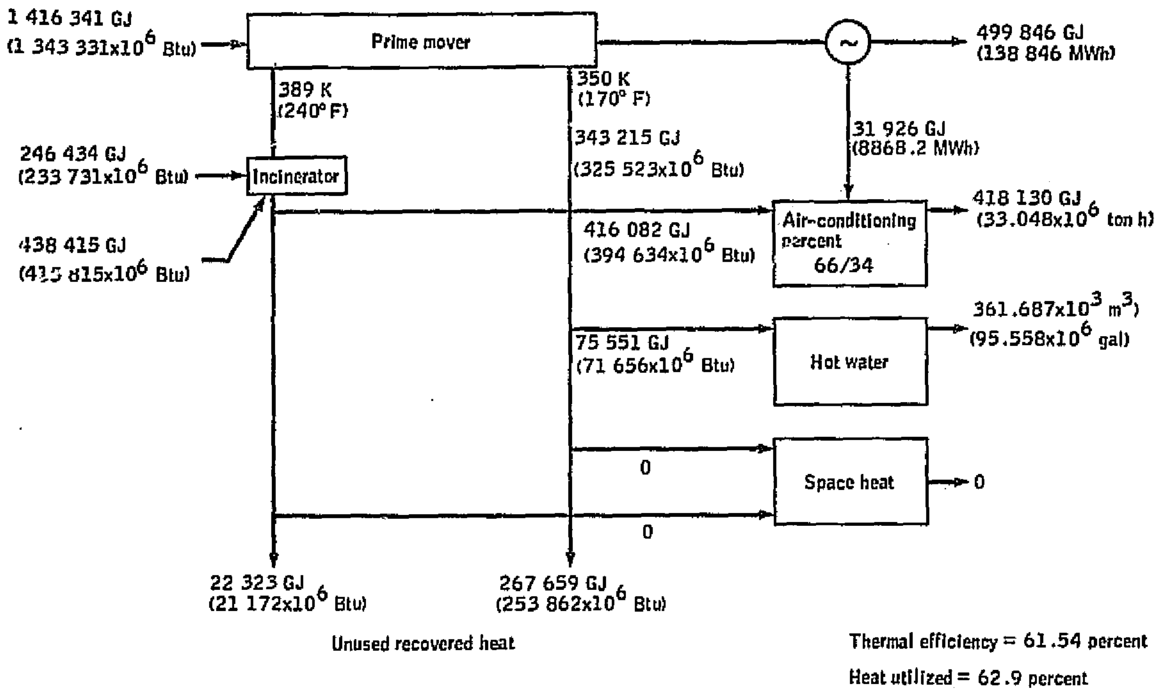
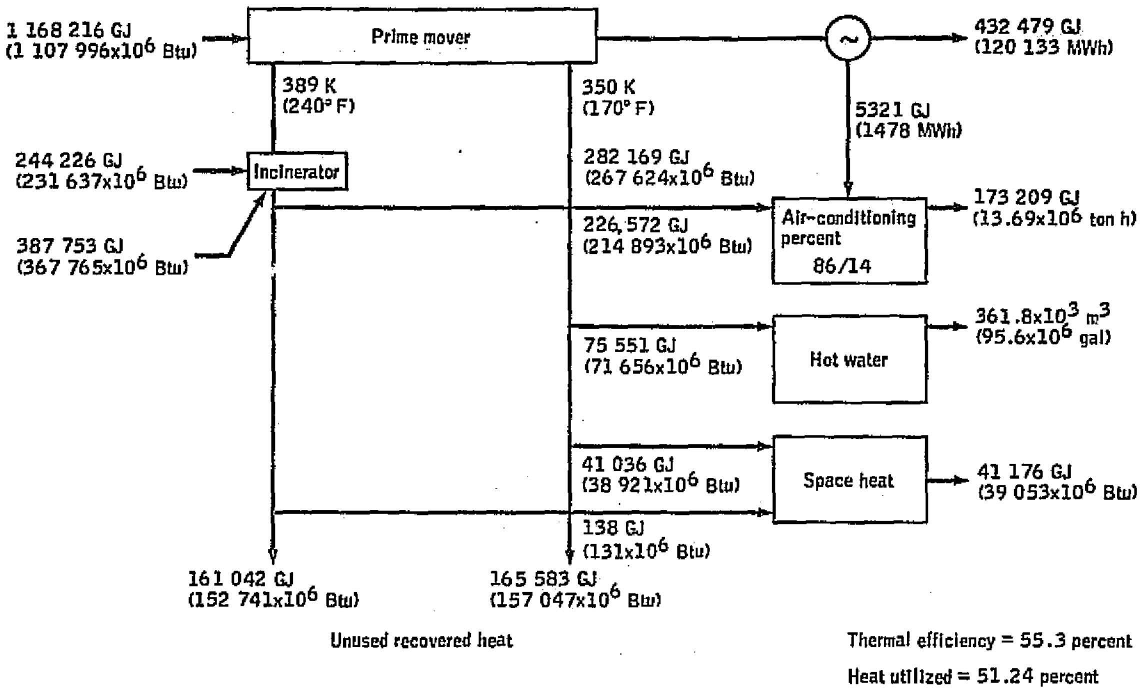


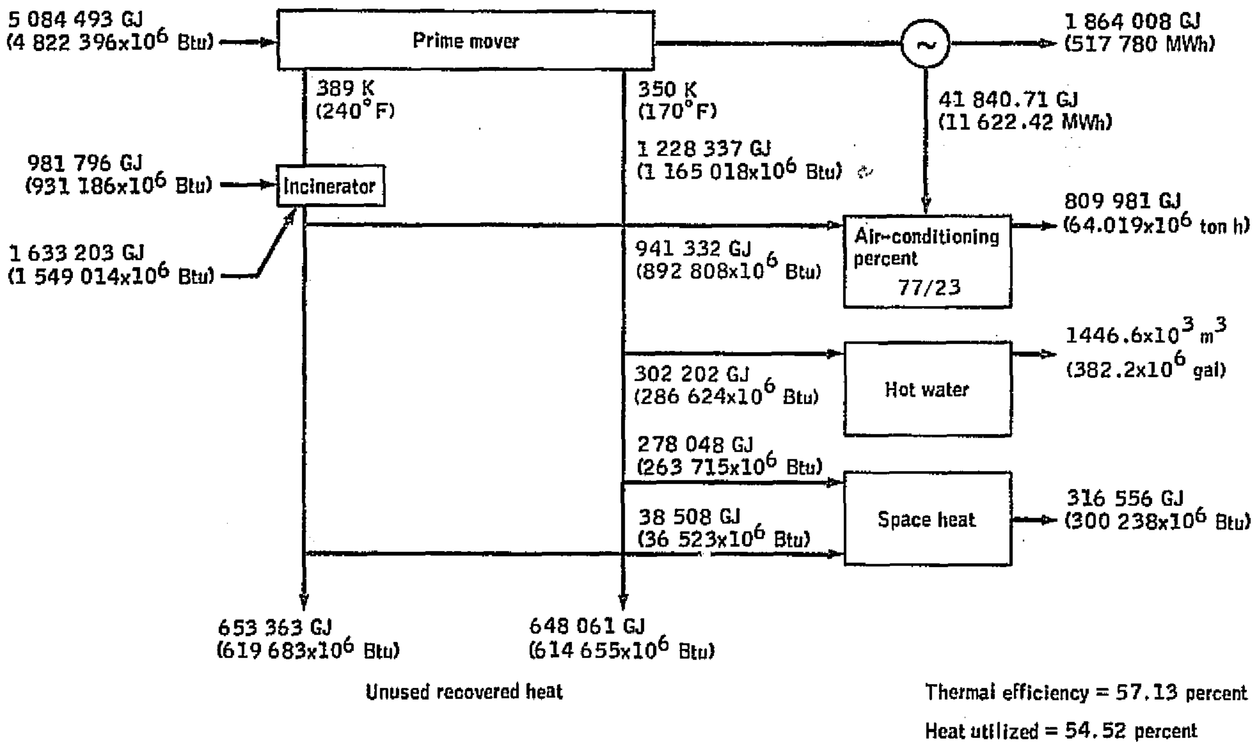
(c) Summer.



(d) Fall.

Figure C-68.- Continued.

C-4



(e) Annual season.

Figure C-68.- Concluded.

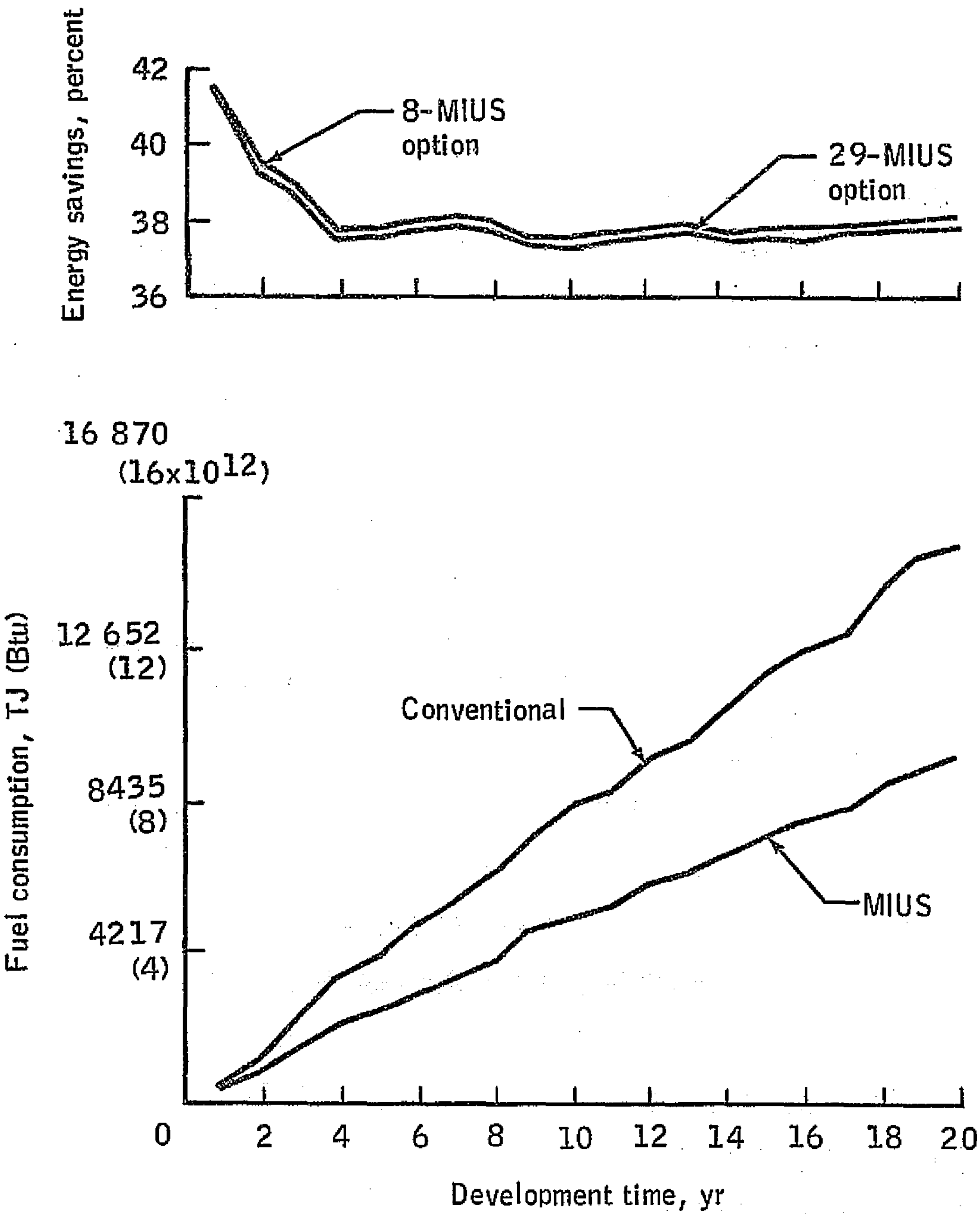


Figure C-69.- Summary of annual energy savings and fuel consumption.

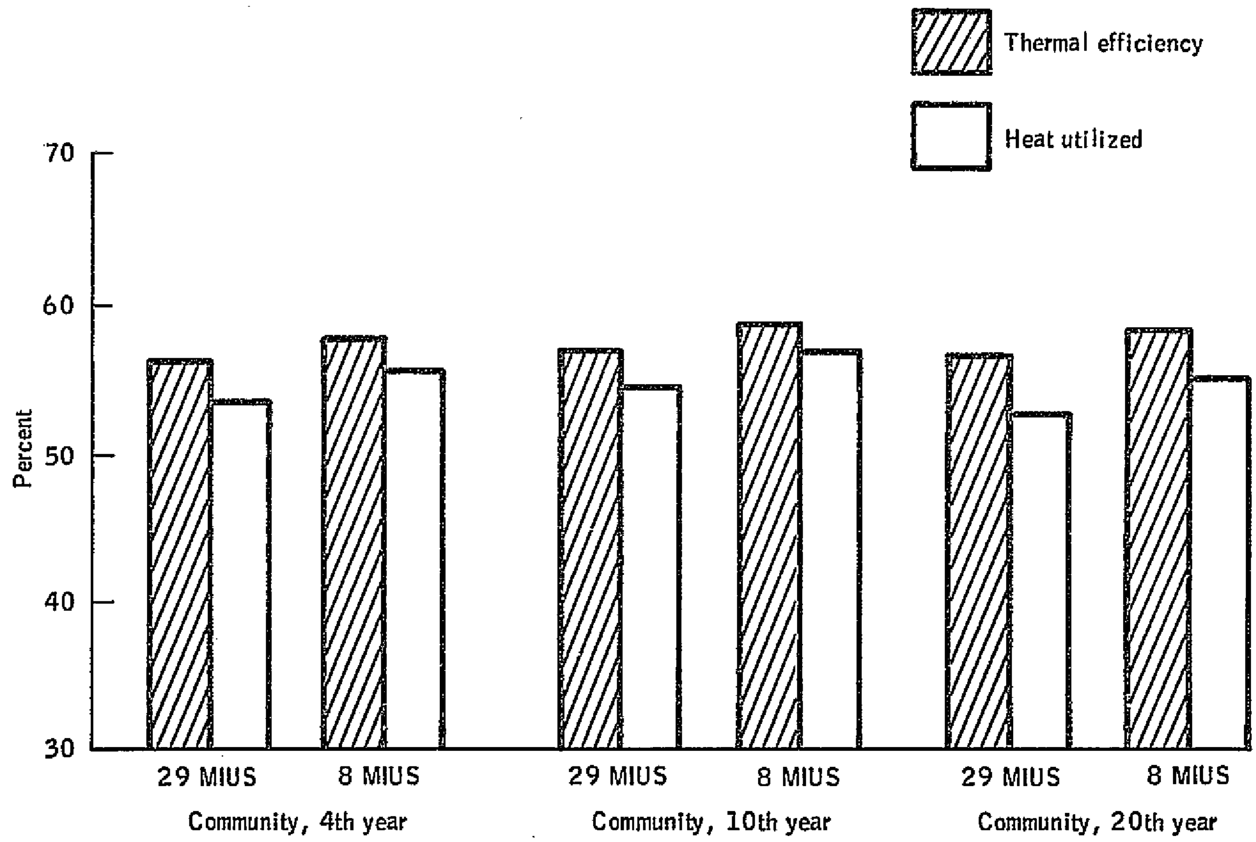


Figure C-70.- Summary of annual MIUS thermal efficiency.

APPENDIX D

ENVIRONMENTAL IMPACT SUPPORTIVE DATA

AIR POLLUTION

The major pollutants to be considered in the atmosphere are carbon monoxide (CO), nitrogen oxides (NOX's), hydrocarbons (HC's), ozone, peroxyacetyl nitrate (PAN), and particulates. The change from a rural area to a residential or urban-commercial area will increase all of these air pollutants. Probable pollutive effects that can be attributed to housing will be estimated, and this will provide the background for evaluating the changes in pollution levels caused by the modular integrated utility systems (MIUS).

Washington, D.C., data have been used as representative of the location of the selected community model, Columbia, Maryland. The contribution to pollution in the Washington-Baltimore area by the MIUS study community can be estimated as proportional to the fraction of the 1980 population of the community to the total Washington-Baltimore population. The total population in the Washington-Baltimore area in 1980 is estimated at 6 100 000 (ref. D-1). Thus, the study community population of 110 000 represents about 2 percent of the total population, and about 10 percent of the total increase in population between 1970 and 1980.

Several types of estimates can be made on the expected pollutant levels in a community supported by MIUS and in a community supported by conventional facilities. In such a community, three types of pollution sources exist: the automobile, the prime mover supplying electricity, and the incinerator and heating plant. The pollutants from these sources are (1) particulates, which settle out of the stack gases and are a localized problem; (2) oxides of sulfur, which react strongly with material in the environment; (3) CO, which diffuses and mixes in the atmosphere but does not react so strongly with the environment as to be rapidly scrubbed from the atmosphere; (4) and NOX's and HC's, which on release to the atmosphere react with each other to form new pollutants.

Control of these pollutants will be considered at two levels. First, there are Federal, State, and local regulations that limit the amount of pollutant released per unit of fuel burned. These regulations apply to particulates, oxides of sulfur, NOX's, and HC's. Second, the pollutants from the MIUS stack, when combined with the background, should not exceed the Federal Air Quality Standards (FAQS), shown in table D-1.

Total Amounts of Pollutants

The emissions from a typical MIUS diesel are shown in table D-2. Table D-3 shows these emissions as normalized emission data (per 1 gigajoule (per 1×10^6 Btu)) compared to allowed emission rates. Conventional powerplant emission rates are shown in tables D-4 and D-5, and normalized emission data compared to allowed emission rates for a conventional powerplant are shown in table D-6. Table D-7 compares the total emissions per year for MIUS and conventional powerplants. These tables indicate that MIUS produces about the same amount of particulates as a conventional oil-fired powerplant at the same fuel rates. However, the conventional powerplant requires 35 percent more fuel to produce the same services to the community.

Sulfur dioxide (SO_2) emissions for MIUS are based upon a 1 percent by weight of sulfur in the fuel. This is probably a pessimistic estimate because it is an upper limit for no. 2 diesel fuel, but it allows quick estimates to be made of other levels of sulfur in the fuel. The increased fuel requirements for a conventional plant indicate that MIUS, using 1 percent sulfur fuel, would release about the same amount of sulfur oxides per unit of electricity as the average oil-fired conventional powerplant.

The NOX's for the MIUS are a problem area. The MIUS produces approximately 10 times more NOX's than does a conventional plant, and averages about 15 times the allowed limit.

Method of Evaluating Local MIUS Pollution Effects

The maximum concentration and the distance at which ground concentrations occur are a function of stability criteria and stack height (ref. D-4). The data are shown in figure D-1 and can be generalized as

$$\frac{Xu}{Q} = Kx_{max}^{-n}(S,h) \qquad \text{(D-1)}$$

where X = concentration of pollutant, g/m^3

u = wind velocity, m/sec

Q = emission rate, g/sec

K = proportionality constant $\left(m^{n-1}\right)$

x_{max} = the distance at which maximum concentration occurs as a function of S, the Pasqual stability criteria, and the stack height h

n = line slope from figure D-1

The maximum pollutant concentration resulting from a source can be normalized in terms of the concentrations allowed by FAQS as follows.

$$N_i = \left[\frac{Q_i}{C_i(t)}\right]\left[\frac{Kx_{max}^{-n}(S,h)}{uA(t)B_i}\right] \tag{D-2}$$

where N_i = the fraction of the allowed concentration of the ith pollutant produced by the source at the point of maximum concentration

$C_i(t)$ = allowed concentration of the ith pollutant in averaging time period t

$A(t)$ = a reducing function to allow for wind dispersion when the averaging period is long

B_i = reduction in concentration as defined in later equation

The emission rate Q can be expressed as

$$Q_i = R_i P_i \tag{D-3}$$

where R_i = rate of release of pollutant by the equipment per unit power level

P_i = power level in appropriate units

and substituting in equation (D-2)

$$N_i = \frac{R_i}{C_i(t)}\,\overline{P}_i\,\frac{Kx^{-n}(S,h)}{uA(t)B_i} \tag{D-4}$$

Equation (D-4) can be rewritten

$$N_i = \theta_i \overline{P}_i L_i \tag{D-5}$$

where $\theta = \frac{R_i}{C_i(t)}$, which is a measure of the relative cleanliness of the source

$\overline{P}_i$ = power output averaged over a time period t

$L_i = \frac{Kx^{-n}(S,h)}{uA(t)B_i}$, which describes the stability criteria, stack height, velocity, and hence the location parameters

The downwind dispersion of pollutant is superimposed upon the existing background of pollutant in the area. The allowed concentration at the site is

$$C_i = C_{ia} - C_{ib} \tag{D-6}$$

where C_{ia} = allowed concentration from the emitting source of pollutant i.

C_{ib} = background concentration of pollutant i

or

$$C_i = C_{ia}\left(1 - \frac{C_{ib}}{C_i}\right) \tag{D-7}$$

Subject to the constraint $0 < \overline{P}_i < 1$, let

$$B_i = 1 - \frac{C_{ib}}{C_i} \tag{D-8}$$

where B_i indicates the reduction in concentration to account for background pollutant. Then

$$N_{is} = \frac{\theta_i \overline{P}_i L_i}{B_i} \qquad \text{(D-9)}$$

where N_{is} is the normalized maximum concentration of pollutant under actual conditions.

Table D-8 shows values of θ and $\theta/(\theta$ NOX) for an MIUS prime mover. From these data, it is obvious that the MIUS has only two pollutants of significance: NOX's and sulfur. If the local concentration of NOX's is satisfactory, then all other pollutants will be at, or below, maximum FAQS limits. A possible exception is sulfur oxides, which require an examination of the terms A(t) and B_i in the previous equations.

The function A(t) arises from two sources. First, the wind direction is usually reported in 16-point increments, but it may wander considerably within any one of these sectors. While the wind direction is considered constant under this condition, Turner's calculations are considered valid for a sampling period of 10 minutes. For longer periods, the concentration drops as $t^{-1/n}$, where n is some value between 5 and 6. A 24-hour sample is estimated to be approximately 0.36 of the peak 3-minute value, without any shift in wind direction. Second, throughout a 24-hour day, the wind will shift direction, thus causing a further reduction. Assuming that the annual "wind rose" directions and speeds are all the same, one would further reduce concentrations from the source by a factor of 16. Because the NOX controlling standard is an average concentration for 1 year and because wind velocity will show some variation as well, A(t) was chosen as 50 (which is probably a conservative figure). For SO_2, which is controlled by the 24-hour standard, a factor of 5 was used, a figure that matches approximately the peak concentrations observed by Larsen for 1-day compared to 3-minute concentrations in Washington.

For the B factor, one must know something about the relative contribution of the various sources to a particular pollutant. For example, powerplants contribute about 90 percent of the NOX pollution. If it is assumed that, at the completion of MIUS, all other sources (autos, other MIUS's, drift from Washington) cause a concentration of approximately 50 percent of the allowed limit, then B will be 0.5. Nearly all SO_2 in the atmosphere can be

accounted for from the burning of oil and coal, and can be considered a fairly local problem. Therefore, 3 is chosen in this case instead of 1.

An evaluation of NOX and SO_2 is shown in table D-9. The average power levels required to produce FAQS limits are estimated in the last column. The 36- and 100-megawatt values are considerably higher than the average power output from any single MIUS plant.

In summary, the MIUS plant presents no local air pollution problem. The FAQS limits will easily be met. However, some difficulty can be expected in meeting emission rates per Btu fuel input set forth by Federal and State regulations.

Local Pollution of CO from MIUS Stacks

Two MIUS configurations for the community are considered in this study. In the first configuration, an MIUS is placed in each neighborhood village center and in the town center, for a total of 29 MIUS's (option I). The alternate configuration has MIUS's located in each village center and in the town center, for a total of 8 MIUS's (option II).

The expected variation in CO concentrations in the completed community as a result of automobile emissions in shown in figure D-2. In this figure, the 8-hour, 0.1-percentile maximum concentration is estimated as 3.3 ppm. The assumption is made that this concentration is a background into which MIUS discharges. It is assumed that the FAQS for 1975 and beyond will be allowed within the community. The total concentration of CO is found by superposition: X(total) = X(background) + X(MIUS). The allowed concentration limit as a result of MIUS is X(total) - X(background). Since X(total) is 9 ppm, the allowed concentration from MIUS is 5.7 ppm.

For a neighborhood MIUS, the 8-hour average power levels for the summer 2-sigma load case are shown in table D-10. The peak emission rate occurs in the 8-hour period commencing at 1500, which should correspond closely to the period of maximum concentration as a result of automobile traffic. The emission rate $Q_{n,m}$ of the neighborhood is calculated as

$$Q_{n,m} = 7.57 \times 10^3 \text{ kW} \times \frac{1 \text{ bhp}}{0.746 \text{ kW}} \times \frac{1.59 \text{ g}}{\text{bhp hr}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} = \frac{4.5 \text{ g}}{\text{sec}} \qquad \text{(D-10)}$$

and

$$X_{n,m} = 5.7 \text{ ppm} = 6.6 \times 10^{-3} \text{ g/m}^3 \quad \text{(D-11)}$$

For this first case, neutral class D stability category will be assumed with a wind velocity $u_{n,m}$ of 5 m/sec. Then, after Turner,

$$\frac{X_{n,m}u_{n,m}}{Q_{n,m}} = \frac{6.6 \times 10^{-3} \times 5}{4.5} = 7.3 \times 10^{-3} \text{ m}^{-2} \quad \text{(D-12)}$$

This would indicate, referring to figure D-1, that a stack height of less than 5 meters would produce concentrations below permissible levels, and that these levels would occur at approximately 0.08 kilometer from the MIUS. If one takes advantage of the fact that the averaging period is 8 hours, then $X_{n,m}$ may be doubled. The ratio Xu/Q would then be too large to fall on the graph, thus indicating a negligible concentration.

For fumigation conditions, which might exist early in the morning, the CO background will be low; 1 ppm is a conservative estimate. Then the allowed concentration from MIUS is 8 ppm or 9 mg/m^3. It will further be assumed that fumigation causes an accumulation of approximately 1.3 ppm in the emission products. The average power level from table D-10 is a stability of 4.53 kilowatts. Criteria F is assumed to apply with a wind velocity of 2 m/sec. Therefore

$$Q_{n,f} = 4.53 \times 10^3 \times \frac{1}{0.746} \times 1.5 \times 1.3 \times \frac{1}{3600} = \frac{3.3 \text{ g}}{\text{sec}} \quad \text{(D-13)}$$

and

$$\frac{X_{n,f}u_{n,f}}{Q_{n,f}A(t)} = \frac{9 \times 10^{-3} \times 2}{3.3(0.51)} = 1.0 \times 10^{-2} \quad \text{(D-14)}$$

Referring again to figure D-1, one can see that Xu/[QA(t)] is too large to fall on the chart; hence, negligible ground concentrations are produced.

A village center MIUS (option II) uses a 7.6-meter (25-foot) stack. For option I, the MIUS has a minimum spacing of 1219 meters (4000 feet). Referring to figure D-3, one can see that, for this stability condition, $(X_{n,m}u_{n,m})/Q_{n,m}$ has fallen by approximately two decades from that found at the peak value at x_{max}. Hence, the pollution from one MIUS has essentially reached background level by the time it is superimposed on that from any other MIUS. For the fumigation condition (fig. D-4), the pollution concentration has dropped approximately one decade, which is negligible if one considers the overall accuracy of these calculations.

The horizontal and vertical dispersion coefficients used to calculate ground concentrations are predicted within a factor of three; however, the "relative confidence" in the values of the horizontal and vertical coefficients decreases for values above approximately 1 kilometer (ref. D-4). Furthermore, these dispersion coefficients are representative over open areas or rural areas. The larger surface roughness and heat island effects of cities change the stability regime over urban areas. In general, more rapid dispersion may be expected for urban areas, although there may be some small-scale pockets where high concentrations occur. A satisfactory practical method that accounts for progressive adjustment of dispersive properties to changing surface conditions has yet to be developed (ref. D-6). The vertical dispersion suffers from similar shortcomings.

The emission of CO in the community is due primarily to automobiles. Over the year, it is estimated that the maximum 8-hour exposure from this source will not exceed 4.5 ppm and that the upper 0.1-percentile 8-hour exposure will be approximately 3.3 ppm. The total emissions per year from MIUS's are approximately 28 percent of those from automobiles. With only a 5-meter stack, these emissions will not produce the FAQS-allowed level of concentration (9 ppm), and downstream plumes will be so diluted as to be not markedly different from the ambient concentration of CO. If one considers the community CO concentration to be the sum of automobile and MIUS concentrations, then the maximum 8-hour levels should be less than 5.8 ppm, and the upper 0.1 percentile of 8-hour exposure concentrations should be approximately 4.2 ppm.

Overall Evaluation of Nitrogen Oxides, Hydrocarbons, and Photochemical Oxidants

Estimates of NOX's and HC's in a community without MIUS.- The total amounts of NOX's and HC's released to the atmosphere by automobiles in the community can be estimated in a manner similar to that used for CO. The emission rates per vehicle mile for 1971 cars (ref. D-7) are 1.49 g/msec/km (2.40 g/msec/mile) for HC's

and 4.10 g/msec/km (6.60 g/msec/mile) for NOX's (such as nitrogen dioxide). The emission rate reduction factors for these two pollutants from urban vehicles for the period 1971 to 1985 are 0.14 for HC's and 0.21 for NOX's (ref. D-8). The resulting release per year for these two pollutants from automobiles at the completion of MIUS is estimated as 200 Mg/yr for HC's and 850 Mg/yr for NOX's.

Total releases for MIUS and conventional plants.- The total HC and NOX emissions per year from MIUS's are 490 Mg/yr or an average of 0.13 g/MJ (0.35 g/(bhp hr)) for HC's and 19 000 Mg/yr or an average of 5.1 g/MJ (13.6 g/(bhp hr)) for NOX's (ref. D-9). For the conventional powerplant, the total emissions are as follows (ref. D-3): coal-fired, 54 Mg/yr for HC's and 5400 Mg/yr for NOX's; oil-fired, 140 Mg/yr for HC's and 4700 Mg/yr for NOX's; and gas-fired, 17 000 Mg/yr for NOX's.

At first, these power-generating projected levels appear startling in that MIUS or a conventional system would contribute more than 80 percent of the HC and NOX pollution in the community; however, it should be recognized that, at present, transportation uses account for 40 percent of these pollutants and that projected reduction (ref. D-9) by factors of 5 (NOX's) to 7 (HC's) will cause the stationary emitters (if their emissions are not reduced) to become the dominant sources of HC's and NOX's. The projected reductions in HC and NOX emissions from urban vehicles may have to be accomplished by changes in lifestyle. From 1963 to 1971, HC emissions were reduced by 83 percent in automobiles (ref. D-6). This was accomplished by elimination of the crankcase blowby, by completely reducing evaporation from fuel tanks by a factor of 5.6, and by reducing HC's in the exhaust by a factor of 3.7. The projected reductions by an additional factor of 7 would appear to be possible only by removing some gasoline engines from the market. The NOX emissions per mile from automobile engines have actually risen by 26 percent from 1963 to 1971, while target goals for 1985 require their reduction by a factor of 5. Again, this appears to be feasible only if the number of engines are reduced.

The kinds of reductions in HC's accomplished in the past for gasoline engines are not possible for diesel engines. The diesel is an inherently cleaner engine; there is essentially no crankcase blowby or evaporation of fuel from the tanks. All HC emissions from diesel engines are in the exhaust, and these emissions are substantially lower than for a gasoline engine. The diesel engine runs on a leaner mixture of air to fuel, and it has higher combustion temperatures. Therefore, these engines inherently emit more NOX's than the gasoline engines, and there is no known developed system for reducing these emissions from diesel engines. However, forthcoming developments for truck engines may assist in alleviating this problem.

Local pollution from MIUS stacks.- Calculations of local pollutant concentrations from MIUS stacks have not been completely carried out, because of the high degree of uncertainty in the background levels of NOX's and HC's. Preliminary calculations without the B factor indicate that the maximum concentrations of NOX's and HC's downwind from an MIUS stack are below FAQS limits.

Oxidants and PAN.- The maximum concentration levels of oxidant in the atmosphere depend upon three variables: the concentration of NOX's in the atmosphere, ultraviolet intensity from the Sun, and the release of HC's to the atmosphere from various sources. A complex set of chemical reactions must take place in the atmosphere, and there is a time delay of 3 to 4 hours in the formation of oxidants after the release of NOX's and HC's. Therefore, local oxidant levels in the atmosphere will be due to the release of precursors at distances of 15 to 20 kilometers upwind, rather than any emission from stacks in the vicinity of MIUS.

Overall Evaluation of Particulates

Regional estimates.- Table D-11 shows that the annual average total of suspended particles in the atmosphere over Washington, D.C., for the years 1961 to 1965 was 104 $\mu g/m^3$. Washington ranked 38.5 in 60 cities for which surveys were conducted. The concentration of benzene-soluble particles was 9.4 $\mu g/m^3$ and the ranking was 21 in 60. Table D-12 shows the sources of these particulate contaminants. Table D-13 shows that, in the proposed community, the mean concentration should be approximately 100 $\mu g/m^3$. Meeting the secondary air quality standards of 60 $\mu g/m^3$ annual average concentration requires a reduction of particulate emissions in Washington from 40 to 45 percent by 1977. The average seasonal variation in concentration will be from 15 to 20 percent of the annual average. The individual 24-hour maximum should not exceed three times the annual average. Suburban residential areas usually have concentrations that are approximately 50 percent of those in the center city (ref. D-10).

If one assumes that the secondary standards are met in the Washington, D.C., area at the time the MIUS community is completed, then the total emission of 17 490 Mg (19 280 tons) in table D-12 would be reduced by 50 percent to 8800 Mg (9700 tons). The completed MIUS community requires 9594.6 TJ/yr (9.1×10^{12} Btu/yr) of energy, which would release 200 Mg (220 tons) of particulates to the atmosphere per year, or approximately 2 percent of the total from the Washington area. The incineration process is estimated to release 27 Mg/yr (30 tons/yr) of particulates. Automobiles in the community will also release smaller amounts of particulates. As was noted in the regional description of the

community, the population in the community is 2 percent of the population of Washington. Therefore, on a regional basis, the community will release approximately the same amount of particulates per person as the rest of the Washington complex.

Table D-12 shows that conventional power facilities contribute 8972 Mg (9890 tons) of particulate in the Washington area. Estimating that the population in Washington at the time of the survey was 2 400 000 people (ref. D-1) and that the community has 4.6 percent of this population, one can then estimate that the conventional powerplant supplying this community would release 408 Mg/yr (450 tons/yr) of particulate. If one assumes that the particulate emissions from automobiles remain approximately the same as those given in table D-13, then the automobiles in the community should release approximately 272 Mg/yr (300 tons/yr) of particulates. Total emissions from the new community would be 499 Mg/yr (550 tons/yr) from an MIUS installation and automobiles. With conventional facilities, the equivalent release to the atmosphere of the region is 680 Mg/yr (750 tons/yr).

Local effects.- In assessing the concentration of particulates downwind from an MIUS stack, the greatest uncertainty is the background level of particulates. One estimate is that the downtown area of Washington will achieve the secondary standard of 60 $\mu g/m^3$ average annual concentration. The new community may be considered to be suburban; therefore it has an annual average concentration of approximately 30 $\mu g/m^3$, as discussed in the section entitled "Regional Estimates." Under these conditions, the average emission rate Q is 200 Mg/yr (220 tons/yr) or 6 g/sec for all MIUS's, and the emission rate for option I is 0.2 g/sec. Then, for average conditions, stability class D, a wind velocity u of 5 m/sec, and a 1.5-meter (5 foot) stack, the ratio Xu/Q is 0.0055. The maximum concentration downwind at average power consumption from the stack is 6.6 $\mu g/m^3$ or approximately 10 percent of the allowed FAQS. The distance between MIUS's attenuate concentration so there is seemingly no effect between MIUS's.

If one considers average concentrations over a year, the downstream concentration should be reduced by a factor of at least 15 to 20 to allow for time averaging and variations in wind direction. If this is done, the concentration from the stack is negligible compared to the concentration from the background.

At average power levels, the maximum particulate output from the option II configuration is not more than four times the option I configuration. The maximum concentration downwind from option II would not be higher than about four times the concentration above, and the ambient background might increase by four, which would yield a total concentration of 56 $\mu g/m^3$.

Cooling Water Spray

The cooling pond operation typically has a drift loss (evaporated water) of approximately 1 percent of the water being sprayed. This material contains dissolved solids that can form a corrosive layer on the material on which it falls. In the layout of MIUS, it is planned to keep the spray pond approximately 213 meters (700 feet) from the nearest occupied area. It is therefore estimated that essentially no drift will reach the occupied areas adjacent to MIUS.

THERMAL POLLUTION

Air Thermal Effects

There is a well-known heat-island effect around built-up areas. Older surveys have shown that the annual average temperature difference between cities and adjacent rural areas for the period 1940 to 1968 averages approximately 29 percent over the entire year. Peterson's data (ref. D-11) show the diurnal variation of temperature for February and July in Vienna and one of its suburbs (fig. D-5). More recent surveys in U.S. cities indicate an inversion approximately 61 meters (200 feet) over a city. This inversion depends upon windspeed, and, for the completed MIUS community, this windspeed is between 4 and 7 m/sec.

The causes of the heat-island effect are

1. The pavement and buildings in a community absorb and store more solar radiation than does vegetation in rural areas.

2. The energy released in the community has been estimated for 1956 in Vienna to be around one-sixth to one-fourth of the solar input; and in Sheffield, England, for 1965, to be one-third of the solar input. For 1968, in New York City (during the winter), combustion contributed 2-1/2 times the solar input. The growth trend from 1940 to 1985 in the residential consumption of electricity is estimated to increase ninefold, and to double from 1968 to 1985 (ref. D-12). Thus, it is estimated that for the proposed community, energy consumed should be approximately the same amount as the solar input; and, if MIUS is used, the energy released on site will be approximately twice the solar input.

3. The third factor influencing temperature is the blanket of pollutants over the city (including particulates, water vapor, and carbon dioxide) that produce a greenhouse effect over the city. This blanket prevents radiation losses, and slows heat dispersion.

Compared to a community supplied by conventional facilities, the MIUS in the community will increase the amount of released heat by approximately a factor of two; and, because the MIUS releases more carbon dioxide and water vapor, a community so equipped should have a stronger blanket or inversion layer over it.

The overall effect of a thermal island may be somewhat beneficial. During peak solar input, the temperature in the community will only slightly differ from the surrounding countryside; therefore, the peak air-conditioning loads should not be different for a community with MIUS and one without MIUS. The nighttime air-conditioning load will increase during the summer; however, during the winter, raising the outside temperature around buildings will substantially reduce the building heating requirements. In the case of a conventional powerplant, this same heat must be released to a stream where no benefit is likely to be derived.

Water Thermal Effects

In MIUS, process water obtained from treated sewage flows through a series of cooling ponds at each MIUS. These ponds have volumes as follows:

Option I: For 21 MIUS's, the volume is 1699 cubic meters (448 800 gallons); for seven village centers, 4247 cubic meters (1 122 000 gallons); and for one central business district, 11 948 cubic meters (3 156 560 gallons).

Option II: For one central business district, the volume is 11 948 cubic meters (3 156 560 gallons); and for seven village complexes, 6605 cubic meters (1 744 934 gallons).

Process water will flow continuously through these ponds, for which approximately one-eighth of the inlet water will be evaporated; the balance will flow to a large lake covering 116 hectares (286 acres) where it will be retained for an average period of approximately 150 days. The outflow from the cooling ponds cannot exceed 305 K (90° F) without derating the engines. The delay in the community lake is expected to decrease the temperature to some value below 305 K (90° F), which depends upon the average air temperature. The Bureau of National Affairs, Inc. (BNA) has summarized the temperature criteria proposed for interstate and coastal waters (ref. D-13). The proposed and approved temperature criteria are not necessarily established permanently. On the basis of experience, changes may be proposed by the states and approved by the Department of the Interior. Suggestions have been made that the standards should permit the zoning of certain waters for industrial uses. The proposed lake delay time should be adequate to meet or exceed the standards recommended by the BNA (ref. D-13).

NOISE POLLUTION

The external noise standards required by HUD for new construction are shown in table D-14. In meeting these standards, the noise from sources beyond the control of the builder must be considered. These sources include aircraft, roadways, and railways.

Guidelines for evaluating these sources are documented by HUD (ref. D-14). As the community develops, it is expected that air-conditioning equipment outside of single family residences and apartments will produce noise at the adjacent house and/or apartment windows. Performance requirements will be met by (1) deed restrictions, (2) specification of outside equipment meeting the technical requirements of the Air-Conditioning and Refrigeration Institute or the Association of Home Appliance Manufacturers, and (3) any enforceable local ordinance. The methods outlined by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) (ref. D-15) assume that, where internal noise levels are required to specify allowed external noise levels, then the HUD, ASHRAE, or other applicable design criteria would apply. The MIUS plant buildings will be constructed to attenuate the noise from the equipment that they house, so that they meet or exceed the acceptable criteria of table D-14. In the case of MIUS equipment that is outdoors, either sufficient distance to the property line will be allowed or sound barriers will be erected to ensure meeting HUD's acceptable category.

Expected Site Noise Levels

Aircraft noise.- Using the HUD methods (ref. D-14), it can be established that the proposed community lies completely outside the noise exposure forecast (NEF) 30 contour of the local airports; therefore, it will fall within the clearly acceptable category from this noise source.

Traffic noise.- The community diagram has been idealized to permit the study of MIUS. Some rearrangement of site layout would be required in an actual case to account for topography. At that time, provision would have to be made to eliminate dwelling units adjacent to main highways. Where such an arrangement is not feasible, provisions will have to be made for the erection of barriers to sonically isolate residential and highway traffic.

Railway noise.- It is hypothesized that a railroad spur goes to the northeast section of the community primarily to supply oil to MIUS and to provide raw materials to the industrial park. This rail spur is as close to the boundary as can be accommodated. A greenbelt may also be part of this scheme. The distance between

the tracks and adjacent residential area is more than 183 meters (601 feet), with only one nighttime operation for an adjustment factor of 3.3. This is normally acceptable for noise (ref. D-14).

Noise from MIUS.- No known sources of noise from MIUS's will fall in the unacceptable category.

MANAGEMENT OF MIUS ENVIRONMENTAL IMPACTS

Potable-Sewage-Process Water Systems

The community, on its completion, will require approximately 41 640 m^3/day (11 000 000 gal/day) of water for potable use. This water is supplied from an offsite lake. A sewage plant capable of processing this amount of water will be an integral part of the MIUS's. The water from the sewage will be used for lawn watering and MIUS process water. The lawn watering is estimated to use an average of approximately 9464 m^3/day (2 500 000 gal/day) throughout the year. The MIUS plant will reject approximately 3165 TJ/yr (3.0×10^{12} Btu/yr) of heat, which will require the evaporation of approximately 3785 m^3/day (1 000 000 gal/day) of water. The treated sewage water flowing through a series of ponds provides this cooling water. The total flow into the ponds is approximately 37 854 m^3/day (10 000 000 gal/day). After evaporation losses, approximately 34 069 m^3/day (9 000 000 gal/day) will flow out to streams bordering the community. The process water from the MIUS will be cooled prior to entering the pond; and, therefore, little or no thermal pollution of adjacent streams by the outflow from the ponds will occur. The loss by evaporation will increase the concentration of dissolved solids by approximately 10 percent above the raw water supply level. No significant impact on the environment should be associated with this increase. This cascade effect in the use of water saves an annual average of 13 249 m^3/day (3 500 000 gal/day) over a conventional system providing the same services. In areas of acute water shortage, consideration can be given to using the large system as a raw water supply. In this MIUS design, lakes containing 5 299 576 m^3 (1 400 000 000 gallons) are used for storing process water. The average retention time is therefore approximately 150 days, which should be more than adequate time to make the water suitable for use as raw water. If the dissolved solid concentrations are allowed to rise in both the potable water and the outflow, then the MIUS demand on local water supplies could be reduced by a considerable amount. These assessments have been made without taking into account the replenishment of the lakes from rain, and therefore represent a lower limit on further water savings.

Solid Wastes

The early MIUS installations in the community will dispose of solid waste by incineration using starved air chambers, and they will recover the heat of combustion in a low-pressure boiler for various heating and air-conditioning applications. The development of pyrolysis methods for solid-waste disposal is being followed closely, with the view that an alternate disposal method would be available if incineration within the community were banned, as has been done in many metropolitan areas. The pyrolysis products can be burned directly in the prime mover, which makes pyrolysis much more flexible than incineration. As the project matures, a plan to meet the increasing demand for trash removal will be developed and maintained. It is intended to be a flexible program that will optimize collection and disposal systems economically and, at the same time, will assure the protection of aesthetic and environmental values and make practical use of advanced technology. The development of such a management program will include (1) analysis of current and emerging solid-waste collection and disposal technology, (2) assessment of the growth and solid-waste characteristics, (3) the integration of associable planning data such as road network, traffic, land use, soils, geology, and hydrology, (4) the delineation of collection and disposal processes applicable to the particular situation, (5) economic comparisons of the processes, (6) conclusions pertaining to short- and long-term collection and disposal programs, and (7) management system, funding, and operation. Proper regulations will be adhered to in implementing this program whenever it is found to be most environmentally sound and feasible, and the necessary permits will be obtained.

MIUS INTERNAL WORKING CONDITIONS

The MIUS and supporting equipment for the MIUS will be isolated from the general public by fences, locked gates, and doors. Warning signs will be placed on these MIUS boundaries to ensure that the general public is informed of the hazards of entering these areas. Security will also be effected by routine surveillance by the community police.

The area within the MIUS will be restricted to employees or authorized visitors. This area will, in all respects, comply with the standards required by the Williams-Steiger Occupational Safety and Health Act (ref. D-16). The general public is not exposed to the hazards that potentially exist in close proximity to MIUS equipment within the MIUS perimeter.

The administration and enforcement of the Occupational Safety and Health Act are vested primarily in the Secretary of Labor and

in a new agency, the Occupational Safety and Health Review Commission. This environmental impact statement, therefore, treats only those effects to which the general public is exposed and that are external to the MIUS area under the cognizance of the Environmental Protection Agency.

ALTERNATE UTILITIES

Water Management Systems

Water systems consist of three parts: potable water treatment, sewage treatment, and process water. These three systems are interdependent so that, with respect to environmental impact, they must be considered as a single system.

The alternative to the MIUS system would be conventional off-site water supply and sewage treatment plants. In this case, the water supply plant would have to supply a minimum of 3785 m^3/day (1 000 000 gal/day) more than the MIUS system to make up the water evaporated by the MIUS heat rejection system. To prevent excessive concentration of dissolved solids by the heat rejection system, approximately 3785 m^3/day (1 000 000 gal/day) will be required for blowdown. Using MIUS prime movers, these two quantities would increase the potable water requirements of the community by 18 percent. Lawn watering is accomplished by using treated sewage water and requires an average of 9464 m^3/day (2 500 000 gal/day). Thus, to meet average demands, a conventional plant would require 40 percent more capacity than an MIUS, if an MIUS powerplant is used, or more than 22 percent more capacity if conventional power and air-cooled condensers in heating, ventilation, and air-conditioning (HVAC) are used in the community. This latter requirement would raise the power consumption of the community by 10 to 20 percent. The water management system for MIUS has the potential for further water conservation. The coolant system retains the process water for approximately 150 days, a time period which should satisfy most requirements for steam treatment of sewage plant effluent. Careful control of runoff could potentially make the community independent of external water supply with no change in the potable water quality.

Solid-Waste Disposal

The MIUS system incinerates solid waste and recovers approximately 30 percent of the heating value of this waste. This heat recovery is approximately 5 percent of the total fuel requirement of the MIUS serving the community. Two alternatives are possible for the disposal of solid waste: (1) sanitary landfill and

(2) incineration onsite without heat recovery. At completion of the community, the sanitary landfill operation will require approximately 450 221 m^3/yr (365 acre-feet/yr) of landfill for waste disposal. If landfill consists of between 5 and 10 layers, each 0.6 meter (2 feet) thick, then approximately 8 to 16 hectares (20 to 40 acres) of land will be lost for any use for some period of time each year. This landfill operation will have problems with the prevention of leachate contamination of ground water or aquifer, and possibly air pollution problems that are due to decay gases escaping the landfill area.

The use of incinerators provides an inert landfill material, which is between one-fifth and one-fourth the volume of solid waste, and which would require 1.6 to 4 hectares (4 to 10 acres) of landfill per year. This land could be available for building or agriculture almost immediately. Some market has been found for the residual material from incinerators for use as aggregate in road construction. If one assumes that a market can be found for this material, then the landfill requirements can be reduced to zero. A second advantage to incineration is the reduction of transportation cost to the landfill site. The aggregate is approximately 20 to 25 percent of the weight and is higher in density. Both of these factors reduce the cost of transportation to the landfill site. Finally, the emissions from an incinerator are well below any limit that would preclude the use of an incinerator or incinerators onsite.

The fuel value of solid waste is approximately 15 percent of the fuel used in an MIUS installation. The usable recovered heat will reduce the fuel consumption of MIUS by approximately 5 percent. The use of remote potable water and sewage treatment plants will require significantly higher transportation costs to move the raw water and sewage between the community and these plants. The incineration of the solids recovered in the sewage plant has the potential of producing approximately 1 percent additional decrease in fuel requirements for MIUS.

The remote sewage plant can have no smaller capacity than the MIUS's community plant(s); and, if water-cooled HVAC is used in the community, the plant may have to be 20 percent or larger than an MIUS system. Because sludge in the MIUS water management system is disposed of in MIUS incinerators, a conventional plant may have to provide incineration facilities; and these facilities may or may not be integrated into the solid-waste disposal and heat recovery system, as they are in MIUS.

From both a water conservation and fuel economy standpoint, the MIUS water management system offers significant improvement over the conventional systems. Also, the system offers potential expansion through recirculation to make the community independent of outside raw water supplies.

Electrical and Thermal Energy Supplies

The alternative to the MIUS electrical plant is the conventional electrical grid. Boilers may also be required to provide heat and hot water. The use of conventional facilities requires the consumption of 14 761 TJ/yr (14 × 10^{12} Btu/yr) of fuel compared to 9489 TJ/yr (9 × 10^{12} Btu/yr) for an MIUS facility. Except in the case of NOX's, the conventional plant releases approximately the same weight of pollutants into the atmosphere as MIUS does; therefore, it provides no clear advantage in reducing the total mass of pollutants released into the region. The NOX's released by MIUS significantly reduce fuel savings. Emission control devices must be developed not only for the MIUS prime mover, but also for conventional facilities. During the first few years of community development, MIUS will not contribute significantly to NOX pollution of the region, nor is it a significant local hazard. Emission control devices are under study, and it is believed that this problem will be solved early in the community development.

Approximately 50 percent of the MIUS fuel saving over conventional plants is connected with recovered heat used for hot water, heating, and air-conditioning. The availability of large amounts of water from the sewage plant permits the use of cooling ponds for the operation of central air-conditioning plants, which are about twice as efficient as air-cooled air conditioners. Thus, the use of conventional electrical facilities and conventional heating systems requires higher fuel expenditure without any significant reduction in pollution.

The MIUS plant will release about twice the thermal energy to the environs of the community as conventional facilities release. However, this energy will not increase the peak air-conditioning load, and it may provide some fuel savings during the heating months.

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TABLE D-1.- STANDARD GEOMETRIC DEVIATIONS AT WHICH "CONTROL" SWITCHES FROM ONE STANDARD TO ANOTHER

[From ref. D-2]

Pollutant	Type of standard	Standards						s_g day[1] if both standards achieved at same time	Continuous air monitoring program s_g day (2)		
		Annual maximum for average time, $\mu g/m^3$					Annual geometric mean of 24-hr averages, $\mu g/m^3$				
		1 hr	3 hr	8 hr	24 hr	1 yr			Min	Median	Max
CO	Primary and secondary	40 000		[2]10 000				4.60	1.36	1.17	1.70
HC (nonmethane)	Primary and secondary		160 (6 to 9 a.m.)								
NOX	Primary and secondary					100					
Oxidants	Primary and secondary	160									
Particulate matter	Primary				260		[3]75	1.53	1.25	1.50	2.00
	Secondary				[3]150		60	1.37			
Sulfur dioxide (SO_2)	Primary				[3]365	80		1.77	1.72	1.84	2.12
	Secondary		1300		[3]260			7.22			
					[3]260	60		1.73			

[1]s_g day is standard geometric deviation day.

[2]Approximate deviations observed on National Air Surveillance Network data are listed for particulate matter.

[3]Air quality standard that is expected to "control" at more than half of air sampling sites.

TABLE D-2.- TYPICAL MIUS DIESEL EMISSIONS[1]

Emission	Typical 9-cylinder model		Typical 6-cylinder model	
	Diesel fuel, g/MJ (g/bhp hr)	Dual fuel, g/MJ (g/bhp hr)	Diesel fuel, g/MJ (g/bhp hr)	Dual fuel, g/MJ (g/bhp hr)
NOX	6.26 (16.8)	4.34 (11.65)	4.10 (11.0)	5.55 (14.9)
CO	.19 (.5)	.55 (1.49)	.54 (1.44)	.46 (1.25)
HC	.067 (.18)	.12 (.32)	.09 (.24)	.24 (.66)
SO_2	.30 (.8)	Negligible	.40 (1.07)	Negligible
Particulates	.015 (.04)	Negligible	.057 (.152)	Negligible
Bosch spotometer, smoke	.07 (.2)	Negligible	.26 (.7)	Negligible

[1]Emissions at 720 rpm.

TABLE D-3.- NORMALIZED EMISSION DATA FOR MIUS

Type plant and pollutant	Emission rate, g/GJ (g/1 000 000 Btu)	Allowed rate, g/GJ (g/1 000 000 Btu)	Fractions of allowed emissions
MIUS diesel (diesel or dual fuel)			
Particulates	0.012 to 0.046 (0.013 to 0.049)	0.19 (0.2)	0.065 to 0.247
SO_2	3.5 (3.7)	[1].8 (.8)	4.62
NOX	3.58 to 5.18 (3.78 to 5.46)	[2].3 (.3)	12.6 to 18.2
MIUS incinerator	[3].0000019 (.2×10^{-5})	[3].01 (.01)	.002

[1]Using 1 percent sulfur by weight (maximum for no. 2 diesel).
[2]0.19 g/GJ (0.2 g/1 000 000 Btu) for gas and a weighted average for dual fuel.
[3]g/standard m^3/min.

TABLE D-4.- ESTIMATED EMISSIONS FROM FOSSIL-FUELED STEAM-ELECTRIC POWERPLANTS - 1968[1]

Source	Energy generated, TJ (MWh)	SO_2		NOX		Particulates	
		Amount, Tg (tons)	Percent of U.S. total	Amount, Tg (tons)	Percent of U.S. total	Amount, Tg (tons)	Percent of U.S. total
Coal-fired	2 466 000 (685×10^6)	14.1 (15.5×10^6)	46.69	2.7 (3.0×10^6)	14.57	5.1 (5.6×10^6)	19.79
Oil-fired	374 000 (104)	1.2 (1.3)	3.91	.4 (.4)	1.94	.02 (.02)	.07
Natural gas	1 094 000 (304)	Negligible		.5 (.6)	2.91	Negligible	
Total	3 935 000 (1093)	15.2 (16.8)	50.60	3.6 (4.0)	19.42	5.1 (5.62)	19.86

[1]Source: National Air Pollution Control Administration (ref. D-3).

TABLE D-5.- POLLUTANTS FROM ELECTRIC POWERPLANTS BY TYPE OF FOSSIL FUEL[1]

Pollutants	Average rate of emission		
	Kilograms per megagram of coal (lb/ton)	Kilograms per 10^3 cubic meters of oil ($lb/10^3$ gal)	Kilograms per 10^6 cubic meters of gas ($lb/10^6\ ft^3$)
Nitrogen dioxide	10 (20)	12 462 (104)	6247 (390)
SO_2	[2]19S [2](38S)	[2]18 813S [2](157S)	6.4 (.4)
Sulfur trioxide	[2].3S [2](.6S)	[2]299.6S [2](2.5S)	Negligible
CO	.25 (.5)	4.8 (.04)	Negligible
HC's as methane	.1 (.2)	383.4 (3.2)	Negligible
Aldehydes as formaldehyde	.0025 (.005)	71.9 (.6)	16 (1)
Particulates	[3]17A(1 - E)	[3]10(1 - E)	240 (15)

[1]Source: Compilation of Air Pollutant Emission Factors, NAPCA, Durham, North Carolina, 1968 (ref. D-3).

[2]S equals percent sulfur in the fuel. For example, coal with 2 percent sulfur will emit 76 lb of SO_2 and 1.2 lb of SO_2 per ton of coal burned, assuming no removal of SO_2 from the flue gases. In coal-fired boilers much of the SO_2 is removed with the ash.

[3]Emissions of fly ash are a function of the ash content of the fuel, type of furnace, and efficiency of the control equipment. For a dry bottom, pulverized coal ash, fly ash emissions in lb/ton of coal burned would be $17A(1 - E)$, where A is the ash content of the coal expressed in percent and E is the efficiency of the precipitator expressed as a decimal. For coal having an ash content of 10 percent and a precipitator operating at an efficiency of 97 percent, the rate of emissions would be $(17 \times 10)(1 - 0.97) = 2.55$ kg/Mg (5.1 lb/ton) of coal.

TABLE D-6.- NORMALIZED EMISSION DATA FOR CONVENTIONAL POWERPLANT

[National average of conventional powerplant.[1]]

Type plant and pollutant	Emission rate, g/GJ (g/1 000 000 Btu)	Allowed rate, g/GJ (g/1 000 000 Btu)	Fraction of allowed emissions
Coal fired:			
Particulates	1.10 (1.16)	0.2 (0.2)	5.80
SO_2	3.04 (3.21)	1.1 (1.2)	2.67
NOX	.589 (.621)	.7 (.7)	.89
Oil fired:			
Particulates	.036 (.038)	.2 (.2)	.19
SO_2	2.36 (2.49)	.8 (.8)	3.11
NOX	.444 (.468)	.3 (.3)	1.56
Gas fired:			
Particulates	Negligible	.2 (.2)	NA
SO_2	Negligible	--	NA
NOX	.37 (.39)	.2 (.2)	1.95

[1]National average fuel rate is 10.5 MJ/kW (10^4 Btu/kW).

TABLE D-7.- COMPARISON OF TOTAL EMISSIONS PER YEAR

FOR MIUS AND CONVENTIONAL PLANTS

Pollutant	Total emissions, Mg/yr	Ratio of conventional plant to MIUS plant
MIUS pollutant:		
NOX (18.2 mg/W (13.6 g/bhp))	19 000	--
HC (0.47 mg/W (0.35 g/bhp))	490	--
SO_2 (1 percent by weight S)	10 000	--
Particulates (0.204 mg/W (0.152 g/bhp))	210	--
Conventional pollutant:		
Coal fired		
NOX	5 400	0.28
HC	54	.11
SO_2	10 400	1.04
Particulates	1 000	4.76
Oil fired		
NOX	4 700	.24
HC	140	.28
SO_2	7 100	.71
Particulates	454	2.16
Gas fired		
NOX	254	.01
HC	Negligible	--
SO_2	.26	--
Particulates	9.8	.04

TABLE D-8.- POLLUTANT EMISSIONS FROM DIESEL, θ AND $\theta/(\theta$ NOX)

Pollutant	Controlling[1] standard and averaging time	Controlling amount, $\mu g/m^3$	Emission rate, $\mu g/MJ$ ($\mu g/kWh$)	θ	$\frac{\theta}{\theta \text{ NOX}}$
NOX	Secondary 1 yr	100	4083 to 6250 (14 700 to 22 500)	147 to 225	1
Particulates	Secondary 24 hr	150	56 (203)	1.35	.009
SOX	Secondary 24 hr	260	5944 (21 400)	82	.557
CO	Secondary 8 hr	10 000	186 to 553 (670 to 1990)	.067 to .199	Negligible
HC	Secondary 3 hr (6 to 9 a.m.)	160	67 to 246 (241 to 884)	1.5 to 5.5	.010 to .037

[1]See reference D-2.

TABLE D-9.- LOCAL POLLUTION ANALYSIS

Pollutant	Power level to produce FAQS[1] pollution level, MW
NOX	100
SO_2	36

[1]Based on table 3-1, reference D-5, approximately 50 percent NOX comes from stationary sources.

TABLE D-10.- EMISSION OF CO FROM MIUS NEIGHBORHOOD

FOR 8-HOUR PERIODS, SUMMER 2-SIGMA CASE

8-hr period starting with the hour -	Total emissions, ppm	Hourly average, kW
2400	36.3	4.53
100	37.3	4.66
200	39.1	4.87
300	40.6	5.07
400	42.7	5.33
500	45.2	5.65
600	48.1	6.01
700	50.6	6.33
800	51.6	6.45
900	52.1	6.51
1000	53.1	6.64
1100	55.0	6.88
1200	57.5	7.19
1300	59.1	7.39
1400	60.2	7.52
1500	60.6	7.57
1600	60.3	7.54
1700	57.8	7.22
1800	57.1	6.89
1900	51.6	6.45
2000	47.1	5.88
2100	42.9	5.37
2200	38.9	4.86
2300	37.0	4.63

TABLE D-11.- SUSPENDED PARTICLE CONCENTRATIONS (GEOMETRIC MEAN OF CENTER CITY STATION) IN URBAN AREAS, 1961 TO 1966

[From ref. D-8]

Standard metropolitan statistical area	Total suspended particles		Benzene-soluble organic particles	
	μg/m^3	Rank	μg/m^3	Rank
Chattanooga	180	1	14.5	2
Chicago-Gary-Hammond-East Chicago	177	2	9.5	19.5
Philadelphia	170	3	10.7	12.5
St. Louis	168	4	12.8	4
Canton	165	5	12.7	5
Pittsburgh	163	6	10.7	12.5
Indianapolis	158	7	12.6	6
Wilmington	154	8	10.2	15
Louisville	152	9	9.6	18
Youngstown	148	10	10.5	14
Denver	147	11	11.7	8.5
Los Angeles-Long Beach	145.5	12	15.5	1
Detroit	143	13	8.4	28
Baltimore	141	14.5	11.0	10
Birmingham	141	14.5	10.9	11
Kansas City	140	16.5	8.9	23
York	140	16.5	8.1	34
New York-Jersey City-Newark-Passaic-Patterson-Clifton	135	18	10.1	16
Akron	134	20	8.3	30.5
Boston	134	20	11.7	8.5
Cleveland	134	20	8.3	30.5
Cincinnati	133	22.5	8.8	25
Milwaukee	133	22.5	7.4	42
Grand Rapids	131	24	7.2	44.5
Nashville	128	25	11.9	7
Syracuse	127	26	9.3	23
Buffalo	126	27.5	6.0	56
Reading	126	27.5	8.8	25
Dayton	123	29	7.5	40.5
Allentown-Bethlehem-Easton	120.5	30	6.8	50
Columbus	113	31.5	7.5	40.5
Memphis	113	31.5	7.6	39
Portland (Oreg.)	108	34	9.5	19.5
Providence	108	34	17.7	38
Lancaster	108	34	6.8	50
San Jose	105	36.5	14.0	3
Toledo	105	36.5	5.6	58
Hartford	104	38.5	7.1	46
Washington	104	38.5	9.4	21
Rochester	103	40	6.1	55
Utica-Rome	102	41	7.0	47
Houston	101	42	6.8	50
Dallas	99	43	8.8	25
Atlanta	98	44.5	7.8	36.5
Richmond	98	44.5	8.3	30.5
New Haven	97	46	7.3	43
Wichita	96	47	5.2	60
Bridgeport	93	50	7.2	44.5
Flint	93	50	5.3	59
Fort Worth	93	50	7.8	36.5
New Orleans	93	50	9.7	17
Worcester	93	50	8.2	33
Albany-Schenectady-Troy	91.5	53	6.6	52
Minneapolis-St. Paul	90	54	6.5	53
San Diego	89	55	8.5	27
San Francisco-Oakland	80	56	8.0	35
Seattle	77	57	8.3	30.5
Springfield-Holyoke	70	58	7.0	47.5
Greensboro-High Point	60	59	6.3	54
Miami	58	60	5.7	57

TABLE D-12.- EMISSION INVENTORY OF PARTICULATE MATERIAL

[From ref. D-10]

Source class	Metropolitan area							
	New York/New Jersey, 1966		Washington, 1965-66		St. Louis, 1963		Los Angeles, 1965	
	Mg/yr (ton/yr)	Percent	Mg/yr (ton/yr)	Percent	Mg/yr (ton/yr)	Percent	Mg/yr (ton/yr)	Percent
Fuel combustion	121 935 (134 410)	58.1	17 490 (19 280)	55.4	78 743 (86 800)	58.9	7784 (8580)	18.8
Power generation	36 325 (40 042)	17.3	8 992 (9 912)	28.5	20 321 (22 400)	15.2	4377 (4825)	10.5
Coal	28 778 (31 722)	13.7	--	--	20 321 (22 400)	15.2	--	--
Anthracite	43 (47)	--	--	--	--	--	--	--
Bituminous	28 735 (31 675)	13.7	8 972 (9 890)	28.4	--	--	--	--
Fuel oil	6 888 (7 593)	3.8	20 (22)	.1	--	--	--	--
Distillate	--	--	17 (19)	.1	--	--	--	--
Residual	6 888 (7 593)	3.3	2.7 (3)	--	--	--	--	--
Natural gas	660 (727)	--	--	--	62 (68)	--	--	--
Industrial	30 480 (33 599)	14.5	318 (351)	1.0	35 380 (39 000)	26.5	662 (730)	1.6
Coal	21 266 (23 442)	10.5	122 (135)	.4	34 464 (37 990)	25.8	--	--
Anthracite	7 277 (8 022)	3.5	--	--	--	--	--	--
Bituminous	13 989 (15 420)	6.7	122 (135)	.4	--	--	--	--
Fuel oil	8 681 (9 569)	4.1	165 (182)	.5	620 (683)	.5	--	--
Distillate	1 342 (1 479)	.6	21 (23)	.1	--	--	--	--
Residual	7 339 (8 090)	3.5	144 (159)	.5	--	--	--	--
Natural gas	533 (588)	--	31 (34)	.1	384 (423)	.3	--	--
Domestic	37 261 (41 073)	17.8	2 872 (3 166)	9.1	18 053 (19 900)	13.5	2200 (2425)	6.6
Coal	16 118 (17 767)	7.7	667 (735)	2.1	17 121 (18 873)	12.8	--	--
Anthracite	15 024 (16 561)	7.2	621 (685)	2.0	--	--	--	--
Bituminous	1 094 (1 206)	.5	45 (50)	.1	--	--	--	--
Fuel oil	19 577 (21 580)	9.3	1 668 (1 839)	5.3	609 (671)	.5	--	--
Distillate	13 822 (15 236)	6.6	1 047 (1 154)	3.3	--	--	--	--
Residual	5 674 (6 254)	2.7	621 (685)	2.0	--	--	--	--
Natural gas	1 566 (1 726)	.7	537 (592)	1.7	321 (354)	.2	--	--
Commercial and government	17 868 (19 696)	8.5	5 308 (5 851)	16.8	4 989 (5 500)	3.7	(1)	(1)
Coal	7 384 (8 139)	3.5	3 530 (3 891)	11.2	4 944 (5 450)	3.7	(1)	(1)
Anthracite	4 021 (4 432)	1.9	139 (153)	.4	--	--	(1)	(1)
Bituminous	3 363 (3 707)	1.6	3 391 (3 738)	10.7	--	--	(1)	(1)
Fuel oil	9 883 (10 894)	4.7	1 646 (1 814)	5.2	31 (34)	--	(1)	(1)
Distillate	2 976 (3 281)	1.4	600 (661)	1.9	--	--	(1)	(1)
Residual	6 906 (7 613)	3.3	1 046 (1 153)	3.3	--	--	(1)	(1)
Natural gas	601 (663)	--	1 324 (146)	.4	24 (27)	--	(1)	(1)

[1]Data included with the data given for domestic users.

TABLE D-12.- Concluded

Source class	Metropolitan area							
	New York/New Jersey, 1966		Washington, 1965-66		St. Louis, 1963		Los Angeles, 1965	
	Mg/yr (ton/yr)	Percent	Mg/yr (ton/yr)	Percent	Mg/yr (ton/yr)	Percent	Mg/yr (ton/yr)	Percent
Refuse disposal	37 860 (41 734)	18.0	7398 (8155)	23.4	14 333 (15 800)	10.7	331 (365)	0.8
Incinerator	--	--	--	--	1 542 (1 700)	1.2	331 (365)	.8
Open burning	--	--	--	--	12 791 (14 100)	9.6	--	--
Transportation	31 973 (35 245)	15.2	5665 (6245)	18.0	6 441 (7 100)	4.8	19 536 (21 535)	47.0
Motor vehicles	30 627 (33 761)	14.6	5151 (5678)	16.3	4 264 (4 700)	3.2	15 563 (17 155)	37.5
Gasoline	20 529 (22 630)	9.8	3657 (4031)	11.6	3 719 (4 100)	2.8	14 900 (16 425)	35.9
Diesel	10 097 (11 131)	4.8	1494 (1647)	4.7	544 (600)	.4	662 (730)	1.6
Aircraft	--	--	372 (410)	1.2	191 (211)	.1	3 642 (4 015)	8.8
Shipping	[2]1 346 (1 484)	.6	--	--	608 (670)	.5	[3]331 (365)	.8
Railroads	--	--	142 (157)	.5	1 361 (1 500)	1.0	--	--
Industrial process	18 066 (19 914)	8.6	1007 (1110)	3.2	34 019 (37 500)	25.4	12 578 (13 865)	33.5
Asphalt batching	--	--	--	--	180 (198)	.1	331 (365)	.8
Asphalt roofing	--	--	--	--	--	--	993 (1 095)	2.4
Cement plants	--	--	--	--	3 266 (3 600)	2.4	(4)	--
Chemical plants	--	--	--	--	--	--	(5)	--
Coffee processing	--	--	--	--	34 (38)	--	(5)	--
Coke plant	(5)	--	(5)	--	66 (73)	--	(4)	--
Glass and frit plants	(5)	--	(5)	--	--	--	662 (730)	1.6
Grain industry	--	--	--	--	6 074 (6 695)	4.5	(5)	--
Metals	--	--	--	--	11 279 (12 433)	8.3	2 649 (2 920)	6.4
Ferrous	--	--	--	--	11 242 (12 392)	8.3	1 324 (1 460)	3.2
Nonferrous	--	--	--	--	37 (41)	--	1 324 (1 460)	3.2
Solvent uses[6]	--	--	--	--	--	--	4 962 (5 470)	11.9
Sulfuric acid manufacturing	--	--	--	--	174 (192)	.1	(5)	--
Superphosphate manufacturing	--	--	--	--	202 (223)	.2	(4)	--
Other	--	--	--	--	12 758 (14 063)	9.5	331 (365)	.8
Total	634 756 (231 303)	100.0	86 364.7 (34 790)	100.0	361 512 (147 400)	100.0	95 473 (44 345)	100.0

[2]Both aircraft and shipping.
[3]Both shipping and railroads.
[4]No plants in that metropolitan area.
[5]Data for plants were not reported.
[6]Includes chemical plant emissions of solvents.

TABLE D-13.- DISTRIBUTION OF SELECTED CITIES BY POPULATION CLASS AND PARTICLE CONCENTRATION RESULTING FROM AUTOMOBILES, 1957 TO 1967

[From ref. D-10]

Population	Number of cities selected	Average particle concentration, $\mu g/m^3$									
		<40	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	>200
>3 000 000	2	--	--	--	--	--	--	1	--	1	--
1 000 000 to 3 000 000	3	--	--	--	--	--	--	2	1	--	--
700 000 to 1 000 000	7	--	--	1	--	2	--	4	--	--	--
400 000 to 700 000	18	--	--	--	4	5	6	1	1	1	--
100 000 to 400 000	99	--	3	7	30	24	17	12	3	2	1
50 000 to 100 000	93	--	2	20	28	16	12	6	5	1	3
25 000 to 50 000	71	--	5	24	12	12	10	2	1	2	3
10 000 to 25 000	64	--	7	18	19	9	5	2	3	1	--
<10 000	44	1	5	7	15	11	2	1	2	--	--
Total urban	401	1	22	77	108	79	52	31	16	8	7

TABLE D-14.- EXTERNAL NOISE EXPOSURE STANDARDS

FOR NEW CONSTRUCTION SITES[1]

[Measurements and projections of noise exposures made at appropriate heights above site boundaries]

General external exposure standards category	Criteria
Unacceptable	Exceeds 80 dB(A) 60 min/24 hr Exceeds 75 dB(A) 8 hr/24 hr
Discretionary - normally unacceptable	Exceeds 65 dB(A) 8 hr/24 hr Loud repetitive sounds on site
Discretionary - normally acceptable	Does not exceed 65 dB(A) more than 8 hr/24 hr
Acceptable	Does not exceed 45 dB(A) more than 30 min/24 hr

[1]From reference D-14.

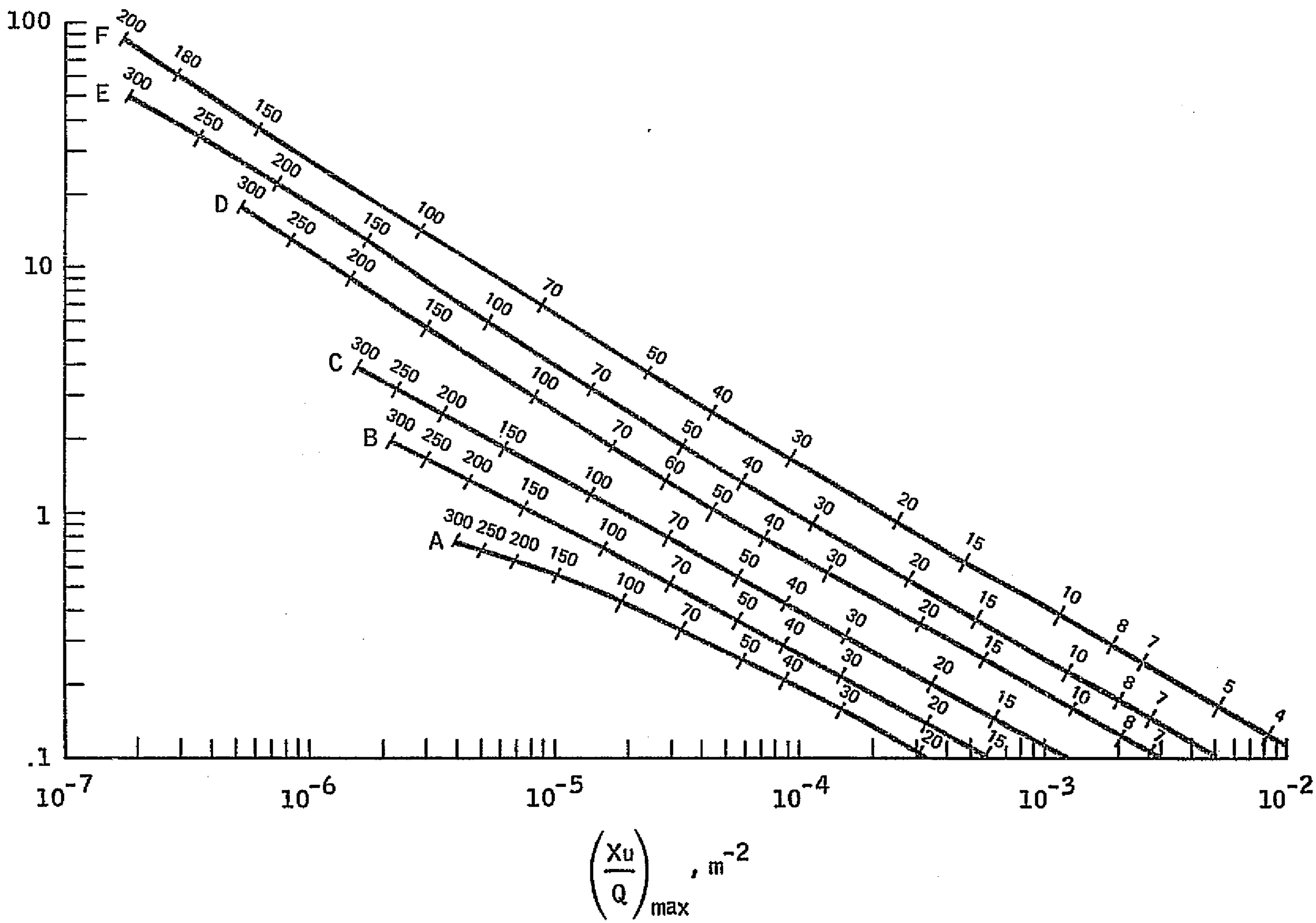

Figure D-1.- Distance of maximum concentration and maximum Xu/Q as a function of stability (curves) and effective height (meters) of emission. (A, B, C, D, E, and F refer to the stability class.)

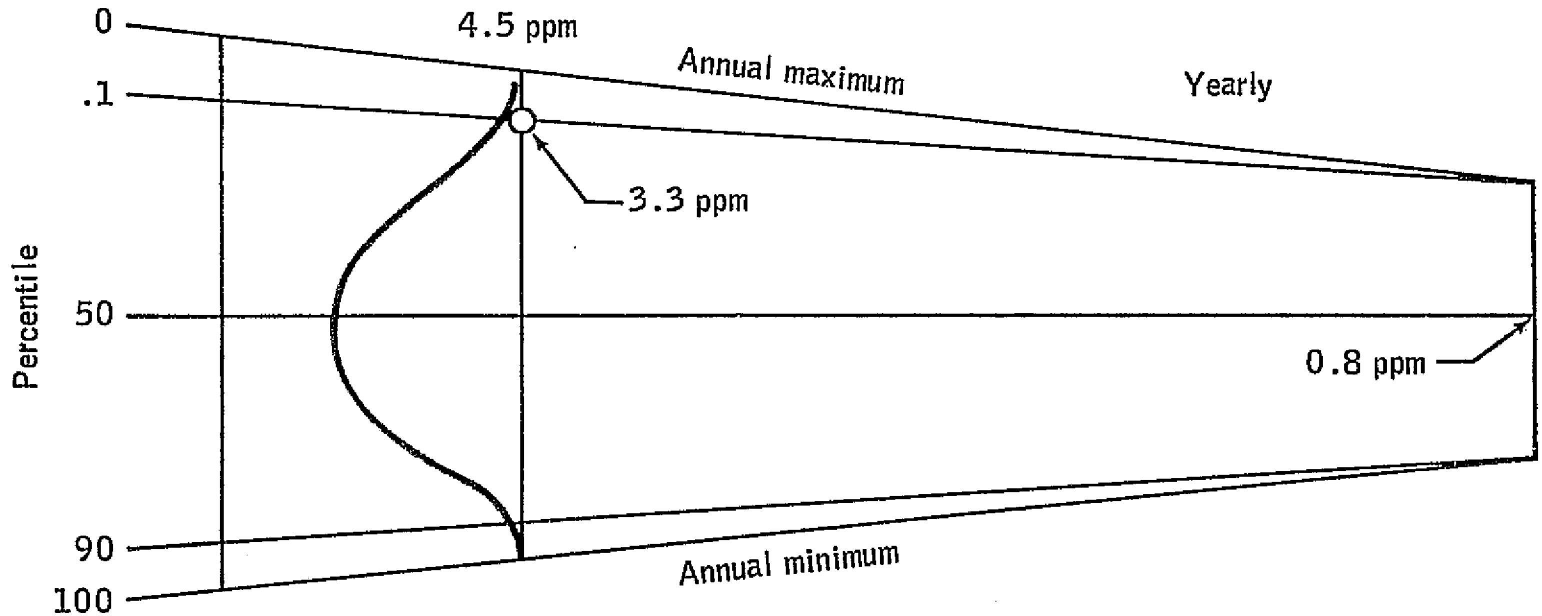

Figure D-2.- Estimated CO concentrations produced by automobiles in the community (ref. D-6).

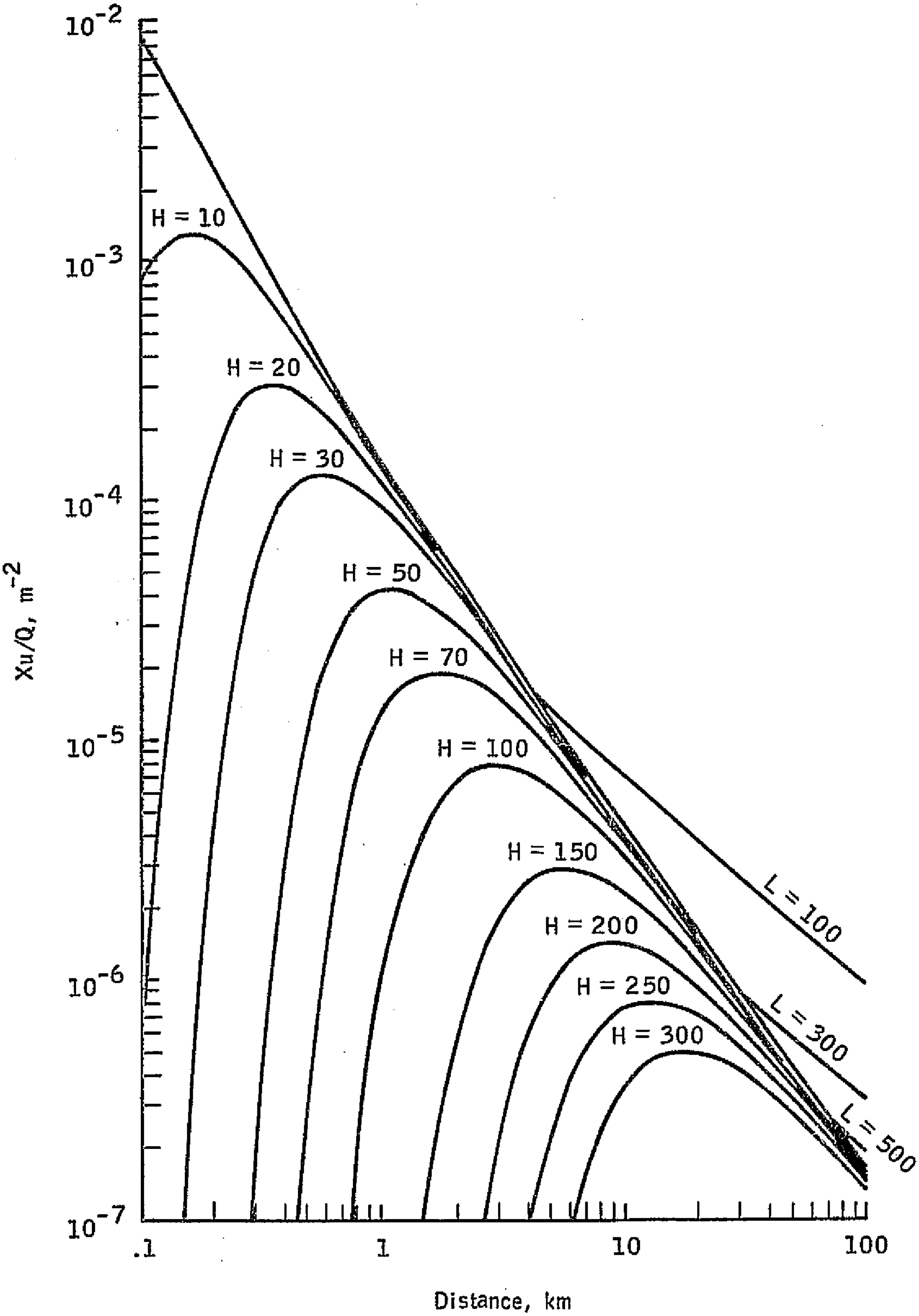

Figure D-3.- A plot of Xu/Q as a function of distance for various heights of emission (H) and limits to vertical dispersion (L) for D stability.

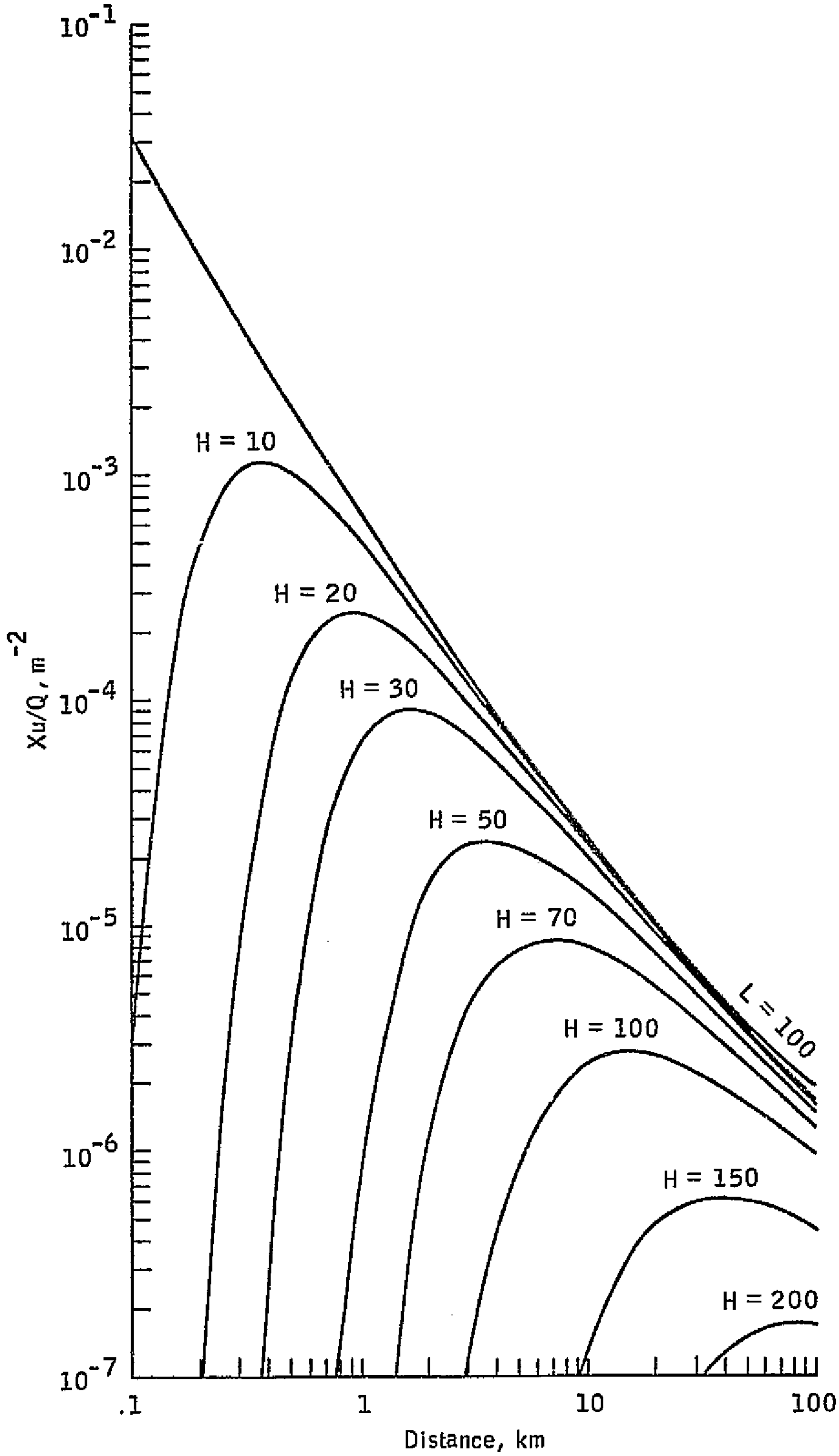

Figure D-4.- A plot of Xu/Q as a function of distance for various heights of emission (H) and limits to vertical dispersion (L) for F stability.

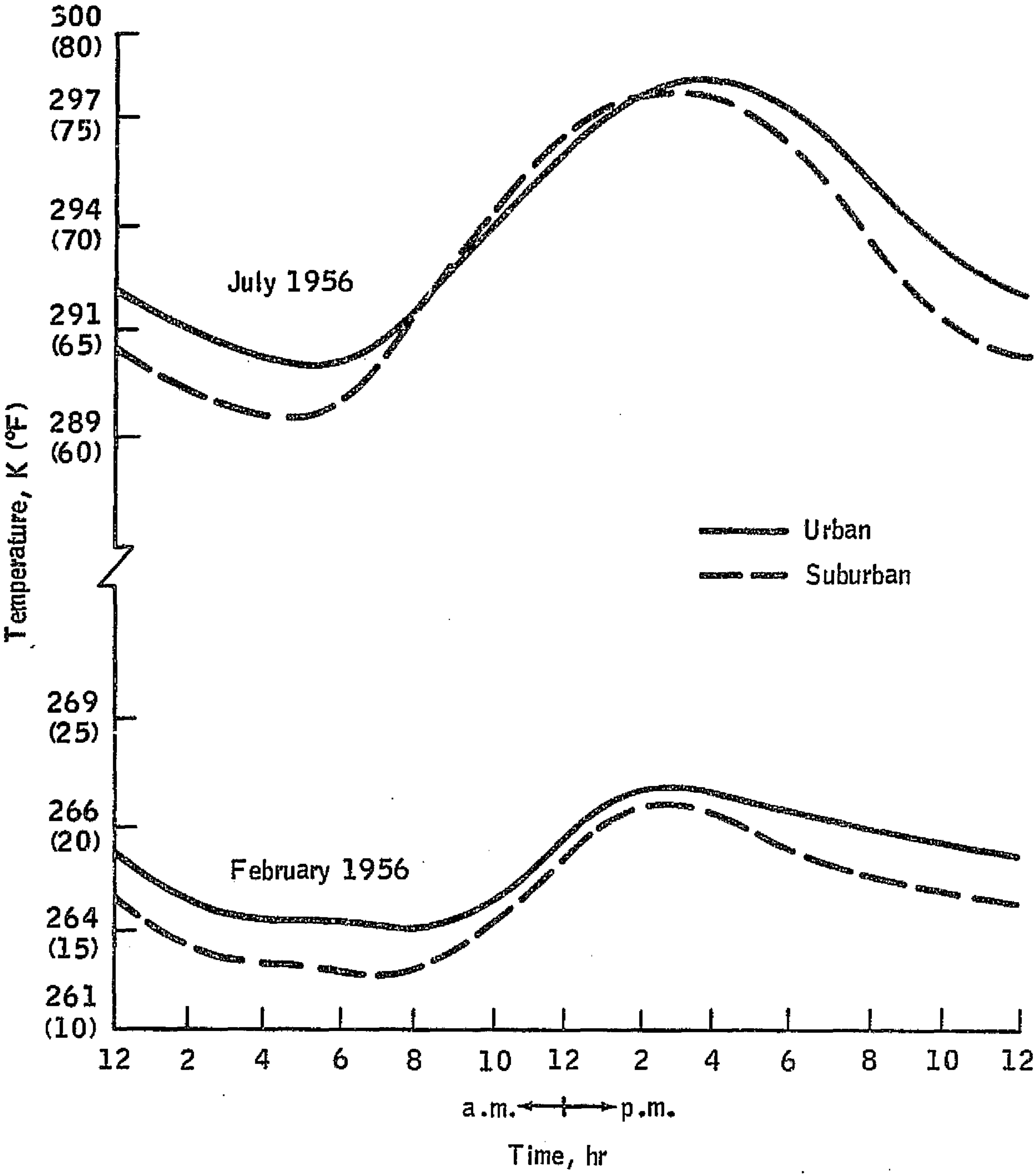

Figure D-5.- Diurnal variation of temperature in Vienna for February and July for both an urban and suburban station (ref. D-11).

APPENDIX E

COST METHODS AND COST ANALYSIS RESULTS

INTRODUCTION

A primary purpose of the community conceptual design study was to assess the economic feasibility of providing utility services to new towns by using the modular integrated utility systems (MIUS) concept. The study encompassed the growth features typical of the large, new, planned suburban communities under development in many areas of the United States. The conceptual community included all features of a residential, social, and commercial development excluding industrial features. The community had a development period of 20 years (from 1975 to 1994) with a planned population of 110 000 by 1994. To effect an equivalent comparison between the costs of conventional utilities and services and MIUS services, it was necessary to specify conceptual conventional utility systems and to develop their costs. Typically, for the sense in which costs are used in this report, conventional services costs are not represented by prevailing rate structures, and the cost of each conventional service may vary considerably depending on many different parameters. Except for the cost of electrical power, which may vary by a factor of about 3 in the continental United States, all other utility services may vary by a factor of 10 or more. The general costing approach was to develop median and average costs for conventional services and to compare the results with the range of utility service costs for representation of an "average" situation.

SCOPE OF THE ANALYSES

Cost and economic analyses for the community study were limited in the cost elements that were considered. Hardware and installation costs comprised the capital outlay; fuel, operating materials, and operating labor were considered under operating costs. Maintenance materials, some hardware replacement, and maintenance labor were considered under maintenance costs. Because the transient buildup period of the conceptual community was considered, an accounting of system residual value at the end of the study was necessary

to effect an equivalent comparison between conventional and MIUS services. This accounting was accomplished by assigning a useful life to the equipment and assuming straight-line depreciation. Elementary economic projections were determined by assuming escalation of material, labor, and fuel costs. Discounted cash-flow (DCF) analyses were conducted to provide an additional mode of cost comparison. The depth of the cost and economic analyses was generally commensurate with the conceptual definition and design. Land costs, construction time, taxes, revenues, and profits were not considered.

Cost guidelines, agreed to with the U.S. Department of Housing and Urban Development before the study, are summarized as follows.

1. Only total costs were considered. There was no consideration of who paid the costs.

2. Projections were made for all items involved in the costing analysis.

3. Distortions as a result of taxes, governmental subsidies, and existing rate structures were not reflected in the data.

4. The effects of mass production of the MIUS were not considered.

5. The assumption was made that the conventional system must add capacity for the satellite community.

SUMMARY OF THE ANALYSES

The following conclusions resulted from the community study cost anslyses.

1. The MIUS utilities and services appear to be cost competitive with conventional utilities and services for large, new-community applications.

2. A major cost saving for MIUS is in electrical power. This saving results from reduced fuel requirements and electrical transmission facilities.

3. A major cost saving for MIUS results from reduced water supply requirements.

4. The capital and operating costs of small wastewater treatment plants are not offset by reduced collection costs;

local intermediate-sized-plant capital and operating costs may be cost effective because of reduced collection costs.

5. The increased capital cost of large central air-conditioning systems is offset by reduced maintenance cost.

6. Solid-waste collection and handling costs are not reduced significantly by MIUS; however, energy recovery from solid waste appears economically desirable.

7. Cost escalations and DCF analyses, when compared to the sum of costs in current dollars, do not significantly affect the conclusions.

The cost summaries of the community MIUS concepts and the conventional utility service are presented in tables E-1 to E-10. Table E-1 gives a total cost comparison between conventional utility costs and the two MIUS concepts evaluated for the study period (1975 to 1994). A major cost element in the table is that for diesel fuel, which does not represent a realistic fuel for central station conventional electrical power. The variations in fuel cost for central station electrical power are given in table E-2. Table E-3 illustrates the cost comparison on a subsystem level, and tables E-4 to E-9 display additional detail for each conventional system and MIUS subsystem. Table E-10 was developed to show variations in capital and operation and maintenance (O&M) costs for conventional powerplants using different fuels. The capital and O&M cost data for the conventional powerplants were taken from averages of plants that have gone into operation in the United States in recent years. Additional detail on these plants is provided in a subsequent section of this appendix. The results of this additional study do not affect the conclusions originally presented.

COSTING ASSUMPTIONS, RULES, AND METHODOLOGY

This section delineates the general assumptions, which were made for costing, and discusses the methodology used for the costing and economic analysis. The following guidelines were used.

1. The period of community development was from January 1, 1975, to December 31, 1994.

2. Cost data were developed for mid-1973.

3. Cost escalations were assumed at a rate of 3 percent/yr, compounded annually, from mid-1973 for all items

except fuel. The rate of 3 percent was based on the average increase in the wholesale price index for all commodities between 1962 and 1972. Escalation rates for fuel were assumed at 5 percent/yr and 15 percent/yr, compounded annually.

4. A discount rate of 15 percent/yr was assumed. Limited investigation indicated that this was a reasonable historical rate for regulated investor-owned public utilities.

5. The accounting assumptions were as follows.

a. Capital outlays were assumed to be made on January 1 of each year.

b. Accounting for O&M outlays was made as of December 31 of each year.

c. Except for the phased buildup period of the study, no construction time was assumed.

d. The value of capital equipment was not escalated after the capital outlay.

e. Straight-line depreciation over the useful life of the equipment was assumed.

f. Where positive salvage values were used, the salvage value was escalated at 3 percent/yr, compounded annually.

g. Negative salvage values were not used.

h. All outlays were discounted to January 1, 1975.

i. Equipment residual value (without escalation) on December 31, 1994, was discounted to January 1, 1975.

j. Capital outlays for equipment replaced during the study period were at escalated values.

k. Land costs and site preparation costs were not considered.

l. Fixed charges (taxes, interest, insurance, etc.) were not considered.

m. Revenues, profits, dividends, etc. were not considered.

n. When historical data were used to determine mid-1973 costs, adjustments were made for increases in materials and labor costs.

DISCOUNTED CASH ANALYSIS PROGRAM

A simple computer program was developed for use in the community study. The program was designed to sum input data, assess system residual value based on the input data, escalate and sum the input data, and discount and sum the escalated values. Inputs to the program (for the community study) were year-by-year (in mid-1973 dollars) values for capital expenditures, useful life, salvage value, fuel (in 10^9 Btu), electricity (in kilowatt hours), and other O&M costs. The program accepted multiple inputs per year for all items. Fuel inputs and electrical power inputs were converted to 1973 dollars by an appropriate multiplier.

An additional program feature, which was used only for the community solid-waste system, provided for components with a useful life of less than the period of the study to be automatically replaced at the appropriate time, credit taken for the salvage value, and the additional expenditure reflected in the capital outlay sums. For the solid-waste systems considered in this study, numerous components (such as trucks and collection vehicles) had a useful life of less than 20 years. Although a similar situation existed for the heating, ventilation, and air-conditioning (HVAC) and hot-water equipment, a satisfactory data base was available so that replacement costs could be included in the maintenance expense data.

All dollar inputs to the program for the community study were in 1973 dollars. Fuel and electricity inputs were converted to 1973 dollars within the program. Capital costs were escalated at 3 percent/yr, compounded, from 1973 with the yearly evaluation point being January 1 of each year from 1975 to 1994. That is, 1975 capital inputs in 1973 dollars were escalated by $(1.03)^2$ for 1975 dollars; 1976 capital inputs in 1973 dollars were escalated by $(1.03)^3$ for 1976 dollars, and so on. For O&M costs, the assumption reflected in the program was that the accounting would be made at the end of each year. The 1975 inputs for O&M (other than fuel) in 1973 dollars were escalated by $(1.03)^3$ for 1975 dollars; 1976 inputs for O&M (other than fuel), in 1973 dollars, were escalated by $(1.03)^4$ for 1976 dollars, and so on. Fuel costs were handled in the same manner as all other O&M except that escalation rates of 5 percent/yr, compounded, and 15 percent/yr, compounded, were used. Escalated values were discounted at 15 percent/yr to

January, 1975, with discount exponents running from 0 for capital in 1975, and from 1 for O&M costs in 1975. An example of the program output and the results used in the summary data are given in table E-11.

CONVENTIONAL UTILITIES AND SERVICES

Conventional utilities and services were defined in detail and were costed in a manner similar to MIUS costing to effect an equivalent cost comparison. Capital, or initial cost, and annual O&M costs were evaluated. The primary systems and functions that were costed are as follows.

Electrical power:

- Generation
- Transmission
- Distribution
- General plant

Water supply:

- Supply pumping station and supply pipeline
- Treatment plants
- Storage and distribution

Hot water:

- Individual dwelling unit hot-water heaters and individual building central circulating systems for the large buildings

Wastewater:

- Collection
- Treatment
- Disposal (not costed)

HVAC:

- Individual dwelling unit systems for the single-family dwellings, townhouses, and garden apartments; central

chilled- and hot-water systems for the high-rise apartments, commercial, and community buildings

Solid waste:

Typical community residential and commercial collection and transport equipment

Incineration equipment

Landfill equipment

Conventional Electrical Power System

Conventional electrical power costs, except for local distribution, were effectively based on a proportional part of a conventional power grid. The local distribution system was defined in detail and was costed accordingly. The growth of the conventional power grid was assumed to be identical to the growth of the community requirements. (A study of the 1970 Federal Power Commission (FPC) (ref. E-1) projection data indicated that the community requirements increase faster in the earlier years of development and slower in the later years of development than projected grid growth for the period from 1975 through 1990. The variation makes the assumption reasonable.)

To realistically assess mid-1973 replacement costs, a particular powerplant was selected as a cost base for the conventional system. Power generation capital and O&M costs (except for fuel) were based on the Homer City, Pa., 1319-megawatt coal-burning plant that began operation in 1969. The reported capital cost of the plant (ref. E-1) (fig. E-1) was $133/kW. This cost was assumed to be in 1966 dollars, average, for purposes of this study. The fuel energy cost of this plant in 1969 was 10 449 Btu/kWh generated. Transmission and distribution losses, typical of the east central electrical power region, of 8.7 percent of the delivered power would increase the energy cost of delivered electrical power to 11 360 Btu/kWh, which corresponds to the values used in the energy analysis calculations. The proportional part of the electrical power system charged to the community was based on the year-by-year "2 sigma plus 6 percent" peak requirement of the community. This "2 sigma plus 6 percent" peak provides a reserve capacity of 20 to 25 percent over the average peak requirements and is typical of U.S. grid network reserve capacity. A special study indicated that the community peak requirements coincided closely with those of a typical grid, both daily and seasonally, so that no adjustment was necessary for diversity of peak requirements.

Transmission and general plant cost components of the conventional electrical power system were based on the cost of these facilities for the east central power region. The local distribution system for the community was defined, and costs were determined from current equipment cost sources (refs. E-2 to E-7). The O&M costs (except for fuel) were derived from the same data base as the system capital costs. Fuel costs were also taken from references E-2 to E-7. A useful life of 32 years was assumed for the conventional electrical power system and was based on a cost-weighted average of generation, transmission, distribution, and general plant facilities.

To make an equivalent comparison of conventional electrical power costs and the MIUS diesel engine electrical power costs, it was assumed that the conventional powerplant could use diesel, fuel oil, or coal without any change in operating or capital cost. This assumption is not exact; however, some study of the FPC data indicated that this method provides a reasonable approximation of conventional electrical power costs as a function of fuel cost. A subsequent and more detailed study of the variations in plant capital and O&M costs confirmed that the original assumption was valid and reasonable for the cost of conventional electrical power. Results and data related to this latter study are discussed in a subsequent section of this appendix. The logic, calculations, and major cost elements used to arrive at a cost for conventional electrical power are summarized in table E-12.

The conventional electrical power system cost was based on the Homer City, Pa., powerplant, which began operation in 1969. Transmission and general plant costs were based on these facilities for the east central power region as used by the FPC. The following analysis illustrates the method and calculations used to arrive at a 1973 replacement cost for this system.

Assuming that the cost of the Homer City, Pa., plant ($175 167 000) is in 1966 dollars (ref. E-8), the 1968 replacement cost (to make these data compatible with the 1970 Federal Power Survey) was obtained in the following manner.

Labor (ref. E-5) . . . . $4.80/$4.25 = 113 percent
Materials (ref. E-9) . . . . 104.2 percent
(1966 = 97.2; 1968 = 101.3)

Percentages of labor and materials in powerplant construction (ref. E-10) 1965-1967 were as follows: labor, 25 percent; materials, 75 percent. Therefore, the 1968 replacement cost of the powerplant is

($175 167 000) (1.13) (0.25) = $ 49 600 000

($175 167 000) (1.042) (0.75) = 137 000 000

Total 1968 replacement cost of powerplant $186 600 000

For the components of transmission and general plant, the 1970 Federal Power Survey data were used (ref. E-1). From volume I, section 19-5, East Central Region (1968 data), table 19.4, the following data provide the values for the component parts of the electrical power system.

Component	Billion of dollars	Percent
Production	5.8	41.1
Transmission	2.5	17.7
Distribution	5.2	36.9
General plant	.6	4.3

With a powerplant cost of $186.6 million, transmission and general plant costs associated with the Homer City plant would be

Transmission, 17.7/41.1 of $186.6 million	$ 80 500 000
General plant, 4.3/41.1 of $186.6 million	19 500 000
Powerplant	186 600 000
Total 1968 replacement cost of the system not including distribution	$286 600 000

The 1973 replacement cost of the system, not including local distribution, reflects the change in construction labor costs and electrical machinery and equipment from 1968 to 1973 (refs. E-5 and E-9).

Labor . . . . 8.10/4.80 = 1.688
(68.8 percent increase)

Electrical machinery and
equipment . . . . 111.2/101.3 = 1.097
(9.7 percent increase)

For 1973 replacement cost, the percentages of labor and materials in powerplant construction (ref. E-10) would be as follows: labor, 35 percent; materials, 65 percent. Therefore, the 1973 replacement costs are computed as

($286 600 000)(1.688)(0.35) =	$169 100 000
($286 600 000)(1.097)(0.65) =	204 400 000
Total	$373 500 000

which represents replacement cost of the system based on the foregoing assumptions and data base (not including local distribution).

Tables E-13 to E-16 present the major data of the DCF program and the results of conventional electrical power cost analyses. A cost escalation rate of 3 percent/yr was used for all items except fuel. Fuel costs were escalated at rates of 5 percent/yr and 15 percent/yr. A discount rate of 15 percent/yr was used in all DCF calculations.

Conventional Water Supply System

The water supply was assumed to be from a natural source located 15 miles from the community. A pumping station, installed in 1975 and expanded in 1984, was located at the source, and raw water was pumped to the treatment plant located on the perimeter of the community. The raw water was piped through a 42-inch cast iron pipeline assumed to have been installed in 1975. Right-of-way costs and electrical power distribution capital costs for the supply pumps were not considered.

The treatment plant was assumed to have been installed in 4×10^6 gal/day capacity stages as the community requirements increased. The capacity at the end of the study period was 28×10^6 gal/day. The local distribution system was cast iron pipe in sizes from 8 to 42 inches. Two 3.5×10^6 gallon elevated storage tanks (with boost pumps) were assumed to have been installed, one in 1975 and one in 1984. A useful life of 100 years was assumed for the cast iron pipe, 40 years for the elevated storage tanks, and 30 years for the treatment plants and pumping stations.

The O&M costs for the treatment plants were developed using comparative data obtained from numerous operating

facilities and from references E-11 to E-13. The O&M costs for the supply and distribution equipment were assumed to be one-fourth the labor costs required for operating and maintaining the treatment plants.

Tables E-17 to E-20 display the cost results and major input data for the conventional water supply system.

Conventional Hot-Water System

The conventional hot-water equipment that was costed for the community study is typical of that currently being installed in homes, apartments, townhouses, and commercial buildings. Each single-family dwelling was provided with an electric hot-water heater. This equipment was identical to that used for both MIUS options. The townhouses were also provided with individual electric hot-water heaters. The high-rise apartments and commercial buildings were equipped with central hot-water systems with continuously circulating hot water. These systems included oil-fired boilers, heat exchangers, circulating pumps, pressure boost pumps, storage tanks, and thermostatic controls. Distribution plumbing was not costed for either the conventional or the MIUS options.

All capital costs were taken from current component cost data. Useful life and O&M costs were taken from references E-14 and E-15. Maintenance costs were allocated so as to keep the equipment in "like new" condition. Reference E-14 provides maintenance factors for the community-type equipment between 3 and 8 percent/yr of the initial cost. For expediency, a factor of 5 percent/yr was used for all hot-water equipment. Electrical power requirements and fuel oil requirements were determined, and electrical power costs are included in the electrical power system costs.

Tables E-21 to E-24 display costing results and details of the equipment. Because this equipment was unique to each building type, much of the annual summary costing was accomplished by a computer routine developed for use with the HVAC equipment. Details of this computer routine are discussed in a subsequent section of this appendix.

Conventional Wastewater System

Conventional wastewater costs were based on collection system costs and treatment plant costs. Provisions for outfall from the treatment plant were not considered. Costing results and detailed costing data are presented in tables E-25 to E-29.

The treatment plants were located on the periphery of the community and were assumed to be installed in 2×10^6 gal/day capacities as the requirements of the community increased. The total capacity at the end of the study period was 14×10^6 gal/day. Capital cost and O&M costs for the treatment plants were developed from comparative data obtained from numerous operating facilities and from references E-11 and E-13.

The collection system was composed of concrete sewer pipe (in sizes ranging from 8 to 66 inches in diameter), lift stations, and manholes. The gravity system was assumed to have been installed in a flat area and consequently required more lift stations than a typical system. The O&M costs for the collection system were taken as one-fourth the O&M labor costs for the treatment plants. Electrical power costs for the treatment plants and collection system were included in the electrical system power costs. Capital costs for the collection system were largely based on estimates by the Howard Research and Development Corporation for Columbia, Md. (ref. E-16). These cost data were escalated appropriately using the U.S. Department of Labor wholesale price indexes.

After the initial definition and costing of the conventional wastewater collection system, a baseline configuration was specified to be used for conventional costing and for costing both MIUS options. Variations from the baseline configuration were specified as additive and subtractive deltas. These variations are reflected in the annual capital costs given in table E-27.

Conventional HVAC System

The conventional HVAC systems are unique to each building type. Individual dwelling-unit housing (exclusive of the high-rise apartments) used heat pumps with supplementary electrical resistance heating. Four-pipe, central chilled- and hot-water systems were used for all other applications. The chilled-water systems used electrically driven centrifugal compressors. The hot-water boilers were fuel-oil fired.

Capital costs for the HVAC equipment were based on current cost references and included refrigeration machines, cooling ponds, hot-water boilers, fan coil/air handling equipment, thermostatic controls, insulated piping and valves, and pumps. Maintenance costs were taken primarily from reference E-15. The maintenance factors included maintenance of equipment in "like new" condition; therefore, useful life did not enter into the cost analysis in exactly

the same manner as for the other subsystems. Typical maintenance factors for a 20-year period are as follows.

Component	Maintenance factor
Centrifugal compressors	0.7
Self-contained air-conditioning units	1.4
Fan coil units	.6
Circulating pumps	.66
Window air-conditioning units	2.0

Operating costs typically amounted to the cost of electrical power and fuel. Electrical power consumption was initially assessed and costed for individual equipment but was omitted from these analyses because it was also included under the electrical power system costs The HVAC power comsumption was calculated from the following factors.

1. Data for the daily heat load (Btu/day) were taken from building data and weather conditions.

2. For compression chillers, the power load was computed from the heat load and the coefficient of performance (COP).

$$\text{kWh/day} = \frac{\text{Btu/day}}{\text{COP}(3412 \text{ Btu/kWh})}$$

The COP varies with machine type and cooling water temperature; it is generally between 2 and 4.

3. Accessories power load for pumps, fan coils, blowers, etc. were summed and multiplied by the hours of operation.

4. Peak-power loads were determined for each unit to define the required generator capacity.

Because the community buildup occurred over a 20-year period and a discounted cash analysis was required, the analysis of this system became very time consuming.

Therefore, a simple computer program was formulated to simplify the task. The program used matrix multiplication to provide a year-by-year evaluation of costs by building and included the following parameters.

1. Capital cost

2. Operating and maintenance cost

3. Electrical power consumption

4. Heating fuel requirements

5. Operating personnel

6. Delivered service (tons of air-conditioning)

7. Total air-conditioning power required

Tables E-30 to E-34 provide the cost analysis results and additional detail on the conventional HVAC costing.

Matrix A (table E-32(a)) illustrates the unit values for each building type. Matrix B (table E-32(b)) gives the year-by-year schedule of building completions. Matrix C (table E-33(a)) gives the product of A x B, which provided the year-by-year totals of capital, O&M, fuel, electricity, and delivered service. This output was used as an input to the DCF analysis. The program also provided for plotting the results of matrix C, which is illustrated in figure E-2.

Conventional Solid-Waste System

The conventional solid-waste system consists of the local collection equipment, the transport equipment for hauling solid waste to a central incinerator and landfill area located offsite, the incinerators, and the landfill equipment. The results of the costing study and detailed information on the equipment for this system are included in tables E-35 to E-37. The primary difference between the conventional solid-waste system and the MIUS solid-waste subsystem is that the incinerators for the MIUS are located onsite at the village centers and at the town center, and they include heat recovery equipment. The conventional system required one less incinerator than the MIUS system. For the conventional and MIUS solid-waste equipment, a difference in useful life of the trucks (for example, 1975 items 4, 8, and 9, table E-37) used for hauling waste to the landfill was assumed. In the conventional case, a useful life of 5 years was assumed; for the MIUS, a useful life of 7 years was assumed. For the conventional case, all waste

was hauled 15 miles to the landfill, and, for the MIUS, only the ash was hauled 15 miles to the landfill. The assumption was arbitrary. Although the transport capital and O&M costs are reduced for the MIUS service, the additional cost of the heat recovery equipment approximately offsets this savings.

Major capital cost items were Dempster Dumpster equipment, satellite collection vehicles, trucks and trailers, landfill equipment, incinerators, building gravity chutes, and compactor containers. The O&M costs were as follows.

1. Fuel: Fuel was costed at $1.02/10^6 Btu as was fuel for the electrical powerplant. This assumption was used for both the MIUS and the conventional system costing.

a. Satellite vehicles: 3/4 gal/hr, 8 hr/day, 300 days/yr

b. Trucks: 3 gal/hr, 8 hr/day, 300 days/yr

c. Landfill equipment: same as for trucks

d. Incinerators: 1.7×10^6 Btu/ton incinerated

2. Maintenance materials and labor: 5 percent of the capital value of the equipment per year.

3. Operator labor: one operator per mobile vehicle at $10 000/yr total.

4. Electrical power: 10 kWh/ton incinerated.

MIUS OPTION I UTILITIES AND SERVICES

Two concepts for providing MIUS services to the community evolved from the initial study planning. In option I, there are 29 separate MIUS installations. A separate MIUS was planned for each of 21 neighborhoods, 7 village centers, and 1 town center. Because of the size of each MIUS, portions of the equipment were installed at different times, particularly with regard to the electrical power equipment and all distribution and collection equipment.

MIUS equipment was costed by subsystem so that costs could be compared to conventional utility costs. The subsystem breakout and the major equipment categories for these subsystems are summarized as follows.

Electrical power:

- Generation
- Distribution
- Fuel supply

Water supply:

- Source supply station and supply line
- Treatment
- Distribution

Hot water

Wastewater:

- Collection
- Treatment
- Storage

HVAC:

- Refrigeration
- Heating
- Distribution (hot and cold water)
- Heat rejection

Solid waste:

- Collection
- Transport
- Incineration
- Landfill

Control system

MIUS housing

Trenching costs were also considered separately.

Individual MIUS installations were not costed as separate, identifiable systems because of the transient buildup period and the community concept with its required infrastructure. However, an approximate cost summary of a neighborhood MIUS has been made for illustration and is included in table E-38.

Except for water supply treatment plants, wastewater treatment plants, and some historical data on sewage collection costs, all cost data were taken from current data sources. Water supply treatment and wastewater treatment plant costs were developed from comparative data obtained from numerous operating facilities and from references E-11 to E-13. For the conventional sewage collection system, information was also obtained from the cost estimates of the Howard Research and Development Corporation for Columbia, Md. (ref. E-16). All historical data were appropriately adjusted to reflect 1973 costs.

MIUS Option I Electrical Power Subsystem

The option I electrical power subsystem consists of 29 separate powerplants, one for each village center, one for each neighborhood, and one for the town center. Each powerplant was installed in stages; that is, after the initial installation, additional engine-generator sets and transformer equipment were installed. Major items of supporting equipment to the powerplants are the electrical distribution system and a central fuel storage and supply system. Operator personnel costs for the electrical power subsystem, control subsystem, HVAC, and hot-water subsystem have been included under operating costs for the electrical power subsystem.

Capital costs.- A major cost item of the electrical power subsystem is the engine-generator sets with heat recovery equipment and local controls. Each engine-generator set for the village center and neighborhood powerplants is rated at 1750 kilowatts and was costed at \$195/kW. Each engine-generator set for the town center is rated at 4415 kilowatts and was costed at \$175/kW. Costs for these items were based on a composite of data. Other components of the electrical power subsystem were costed in detail from current cost data references, primarily from references E-2, E-4, and E-5. The MIUS building costs have been included under a separate section as have the trenching costs for the electrical distribution system. Trenching costs for electrical distribution are a relatively small cost (approximately 20¢/ft).

Useful life.- A useful life of 32 years was assumed for all components of the system with no salvage value at the end of this time. The 32-year useful life was determined for the conventional power system and was based on a cost weighted average of the components of generation, transmission, distribution, and general plant. No comparable estimates were found for the useful life of diesel powerplants; however, the data in reference E-17 indicate that some powerplants have been in operation for periods in excess of this. The useful-life value enters into the costs only in the unit cost values of mils/kWh and in the escalated and discounted cost values.

O&M costs.- Operator costs for the electrical power subsystem, control subsystem, HVAC, and hot-water subsystem are included under the O&M costs for electrical power and were based on the wages for a class V technician (ref. E-9) with fringe benefits and appropriate escalation to 1973. A total of 70 operators are required for this system by the end of 1994. The no. 2 diesel fuel costs were taken at $\$1.02/10^6$ Btu (approximately 14.3¢/gal delivered). Maintenance material and labor costs were based on data from reference E-17. The 1970-1971 data were escalated to yield mid-1973 values.

The cost data on fuel distribution equipment consisted of required fuel storage capabilities (tanks), distribution pipe sizes, and pumps. No valves for the distribution system were included, and only the fuel storage requirements of the central storage area were costed. The costs of storage tanks for the individual neighborhoods, village centers, and the town center were included in the electrical power distribution system costs.

The baseline requirement for the central storage area was a 10-day storage capacity (approximately 2.2×10^6 gallons). The central storage area was then costed as four storage tanks 45 feet in diameter and 48 feet in height with a capacity of approximately 571 000 gallons each. The tanks were added to the central storage area in four phases, 5 years apart, beginning in 1975.

The piping required for the fuel distribution system consists of a 2.5-inch-diameter main and 1.0-inch-diameter primary and secondary branches. The pipes were coated with three layers of tar and were buried 36 inches in the ground. The pipes for the distribution system were installed at the rate of 1/18 of the total per year for the first 18 years. The fuel distribution system was completely installed at 18 years rather than the 20 years of community development. The pumps for the fuel distribution equipment consisted of three 15-horsepower pumps for the main pipeline system,

eighteen 2-horsepower pumps for the MIUS options I and II, and twenty-one 1-horsepower pumps for the MIUS option I only. All the pumps for each village area were installed in the first year of construction on a particular area. The major cost items for the fuel distribution equipment are as follows.

Item	Unit cost, 1973 $
Fuel storage tanks (including foundation)	33 000.00 ea.
Pumps (1 to 15 hp)	646.00 to 1563.00 ea.
Piping (1- to 2.5-inch diameter)	0.95 to 2.12 per ft.

The results of the costing study and detailed information on the equipment for this subsystem are included in tables E-39 to E-44.

MIUS Option I Water Supply Subsystem

The same basic assumptions were made for the MIUS water supply subsystem as for the conventional system. Water was obtained from a natural source located 15 miles from the community. Raw water was pumped to the community for local treatment. Except for the water treatment plants, all cost data were taken from current cost data (refs. E-2 to E-5). The water-treatment-plant capital and O&M costs were based on historical data and were escalated appropriately to obtain 1973 costs.

A major difference between the MIUS and the conventional system water supply costs resulted from the reduced requirements of the MIUS community. Engineering estimates indicated that a 48-inch supply line was required for the conventional community, whereas a 42-inch supply line was required for the reduced MIUS requirements. This results in an approximate difference of $6 000 000 in the cost of these supply lines. However, the added cost was not reflected in the conventional system, so that the supply cost to the community would be the same.

Local distribution piping for the MIUS community ranged in size from 1-1/2 inches in diameter to 42 inches in diameter. For pipe sizes 6 inches and less, it was assumed that plastic pipe would be used. A 50-year useful life for

this piping was assumed according to the manufacturer's recommendation.

No elevated storage tanks were used for the MIUS distribution. This concept required continuous operation of pumps for head pressure. Fire protection water was assumed to be from treated wastewater stored in ponds rather than from the fresh water supply. Fire hydrants were omitted from both the MIUS and the conventional system costing.

Treatment plants were installed in four stages as the requirements of the community increased. Three 4×10^6 gal/day capacity plants were assumed and one 2×10^6 gal/day capacity plant was assumed for a total capacity of 14×10^6 gal/day at the end of the 20-year study period. Capital and O&M costs for the treatment plants were based on references E-18 and E-19. Tables E-45 to E-48 provide the costing results for the MIUS option I water supply subsystem and provide detailed cost data on the equipment.

MIUS Option I Hot-Water Subsystem

The MIUS option I hot-water subsystem was identical to the conventional system for the single-family dwelling. Hot-water equipment for the townhouses, garden apartments, high-rise apartments, commercial buildings, and community buildings was similar to that for the conventional system except that water-to-water heat exchangers were used in place of oil-fired burners. The quantity of hot water in both cases was the same. The same hot-water system was used for both MIUS options. The major items costed for the hot-water subsystem included heat exchangers, circulating pumps, insulated storage tanks, thermostatic controls, and individual dwelling unit hot-water heaters.

Tables E-49 to E-52 give the results of the hot-water costing study and include information on details of the costing.

MIUS Option I Wastewater Subsystem

The MIUS option I wastewater subsystem is composed of a conventional gravity sewer collection system (with lift stations) and wastewater treatment plants. Effluent from the treatment plants was put into ponds located throughout the community to be used for fire protection. A wastewater subsystem was included in each of the 29 MIUS installations. Tables E-53 to E-56 give the results of MIUS option I costing and provide details on elements of the cost.

The collection system included concrete sewer pipe in diameters ranging from 6 to 24 inches. Manholes and lift stations comprised the balance of the capital equipment costed. Because of the assumed flat terrain, more lift stations were included than would be found in a typical gravity sewer system.

Capital costs for the collection system were based, in part, on the Howard Research and Development Corporation data (ref. E-16). These costs were escalated to mid-1973 costs through use of the sewer construction cost index given in reference E-20 for the Baltimore, Md., area. Because this index was available only through mid-1970, the average increase per year over a 10-year period was also used to adjust the costs from mid-1970 to mid-1973. An increase in sewer system cost from 1966 to 1973 of 32 percent resulted from this analysis. The O&M labor costs for the collection system were assumed to be one-fourth the treatment plant O&M labor costs. A useful life of 75 years was assumed for the collection equipment based on data given in reference E-18.

The original component data on the collection equipment were modified subsequent to the initial costing, and the modifications were specified, in part, as additions and deletions to the original configuration. The cost variations, in both cases, were absorbed in the first year; and, in table E-55, they are titled as additive and subtractive deltas without further identification of the location of the specific pieces of pipe added or deleted. The algebraic sum of the component values in table E-55 yields the correct annual capital cost data.

MIUS Option I HVAC Subsystem

As for the conventional HVAC equipment, the MIUS option I HVAC equipment is unique to each building. The 3-ton heat pumps for the single-family dwelling units are the major common item. The commercial, community, and high-density dwelling unit buildings are all supplied with hot and chilled water from the central MIUS building. Some differences in building HVAC equipment that should have been common to the conventional system and both MIUS options will be observed in detailed study of the data. This occurred because the equipment for the different concepts was specified at different times in the study. However, the variations are not sufficient to change the conclusions of the study.

For option I, each neighborhood MIUS provides 1644 tons of air-conditioning; each village center MIUS provides 5670 tons, and the town center MIUS provides 17 800 tons when

completely installed. As in the conventional system costing, maintenance factors were used to permit maintenance of the equipment in like-new condition.

An assessment of the piping cost for providing hot and chilled water to the single-family dwellings was also conducted. A summary of the results is given in a subsequent section of this appendix. Tables E-57 to E-60 provide the costing results for the MIUS option I HVAC equipment and provide detailed cost data on components of the system.

MIUS Solid-Waste Subsystem

The MIUS solid-waste subsystem includes the local collection and transport equipment, the incinerators with heat recovery equipment located at the town center and at each village center, the transport equipment for hauling the incinerator residue to an offsite landfill area, and the landfill equipment. Tables E-61 to E-63 provide costing results for the MIUS solid-waste equipment and provide detailed cost data on components of the system. For the conventional and MIUS solid-waste equipment, a difference in useful life of the trucks (for example, 1975 items 4, 8, and 9, table E-37) used for hauling waste to the landfill was assumed. In the conventional case, a useful life of 5 years was assumed; for the MIUS, a useful life of 7 years was assumed. For the conventional case, all waste was hauled 15 miles to the landfill, and, for the MIUS, only the ash was hauled 15 miles to the landfill. The assumption was arbitrary. The primary difference between the conventional and the MIUS solid-waste system is in the location of the incinerators and the addition of heat recovery equipment to the MIUS incinerators. Although the MIUS transport capital and O&M costs are reduced by incineration of the material onsite, this savings is approximately offset by the addition of the heat recovery equipment.

The same solid-waste subsystem was used for both MIUS options. The incineration and heat recovery functions were accomplished at the village centers and town center only, rather than locating incinerators at each neighborhood MIUS. This resulted in a total of eight incinerator facilities for the community in each concept. The MIUS facilities required one additional incinerator over the requirements of the conventional system. No credit was taken for the recovered energy except in a direct cost comparison of the solid-waste disposal costs, because this saving is reflected in reduced fuel and electrical power requirements for the total MIUS services.

The major capital cost items were Dempster Dumpster equipment, satellite collection vehicles, trucks and trailers, landfill equipment, incinerators with heat recovery equipment, building gravity chutes, and compactor containers. Useful life for the equipment is given in table E-63. The O&M costs were as follows.

1. Fuel: Fuel was costed at $\$1.02/10^6$ Btu, as was fuel for the electrical powerplant. This assumption was used for both the MIUS and the conventional system costing.

a. Satellite vehicles: 3/4 gal/hr, 8 hr/day, 300 days/yr

b. Trucks: 3 gal/hr, 8 hr/day, 300 days/yr

c. Landfill equipment: Same as for trucks

d. Incinerator fuel: 1.7×10^6 Btu/ton incinerated

2. Maintenance materials and labor: 5 percent of the capital value of the equipment per year

3. Operator labor: one operator per mobile vehicle at $10 000/yr total

4. Electrical power: 10 kWh/ton incinerated

MIUS Option I Monitor and Control Subsystem

The central control subsystem for both MIUS options was defined and costed as described in reference E-21. Tables E-64 and E-65 provide the costing information in a format consistent with the other portions of this study.

MIUS Option I Buildings

The MIUS option I housing consists of a building in each village center, one in each neighborhood, and one in the town center. In addition, a separate building was costed for the central potable water supply area, which contains laboratory space, storage, administration, and shop areas. The building specifications were as follows.

Building	Specifications
Town center:	
Size, ft	140 by 164 by 25 high
Floor area, ft^2	22 960
Volume, ft^3	574 000
Village center:	
Size, ft	77 by 126 by 25 high
Floor area, ft^2	9702
Volume, ft^3	242 550
Neighborhood:	
Size, ft	63 by 73 by 20 high
Floor area, ft^2	4599
Volume, ft^3	91 980
Water plant size, ft	120 by 200 by 15 high

All buildings were costed at \$14.26/ft^2 floor area plus 75¢/ft^2 wall area for stone-finished, tilt-up concrete walls. These values were based on the 1973 Dodge Building Cost Data (ref. E-3) for warehouse and office building construction of good quality. The Dodge values are unadjusted for regional location. The Dodge reference describes this construction as follows.

Structure.- Reinforced concrete foundation, footings, walls, and slabs. Exterior walls: all perimeter walls brick and block. Office walls: brick and block or curtain wall panels of plate glass, aluminum extrusions, porcelain enamel panels, or precast aggregate finish wall panels. Interior structural framing: grid layout, structural steel framing of columns and beams. Roof structure: steel bar, open web joists, metal deck. Buildup roof and insulation. Office area finished with resilient flooring, ceramic tile toilets, suspended acoustical ceilings.

Plumbing.- Two toilets for office area, toilet and locker room for warehouse. Water coolers, utility and service sinks.

Heating/ventilation.- Rooftop combination heating and air-conditioning units, gas- or oil-fired furnace or electric baseboard heating system for office area. Suspended unit heaters in warehouse.

Electrical.- Combination fluorescent and incandescent lighting system, open strip in warehouse, built-in panels set into suspended ceilings in office complete with diffusers. Fire alarm system.

Special feature.- Sprinkle system in all areas.

Tables E-66 and E-67 provide the costing information in a format consistent with other portions of the study.

MIUS Option I Utility Trenching

Several studies were conducted to compare the costs of various trenching combinations for the MIUS utilities; i.e., potable water, fire water distribution, HVAC, sewer, and electrical. The studies included the following items.

1. Common trench for potable water and sewer; all other utilities separate

2. Common trench for potable water, HVAC, vacuum sewer, and electrical; fire water distribution separate

3. Common trench for potable water, HVAC, fire water distribution, and electrical; gravity sewer separate

4. Utility tunnels

The trenches were assumed to be flat bottomed and dug in soil with a side-slope ratio of 1/2 to 1, horizontal to vertical. The tunnel was a reinforced concrete structure placed in the same type of soil.

An analysis of the costs for the various trenches showed that tunneling was the most expensive method by a factor of about 5 over simple trenching. The analysis also showed that burying the various utilities in separate trenches was more expensive for all conditions except for very large pipe sizes. Finally, it was concluded that the fire water distribution pipe should be buried in the common trench where possible, and the vacuum sewer system should be used if the system is cost acceptable.

The determination of the total utility trenching costs for the MIUS community was completed by assuming an average depth trench for the three areas of the community (neighborhoods, village centers, and central business district). The trenching costs represent costs for excavation, backfilling, compaction, and removal of some of the excess material. The differences in the total trenching

costs for the two MIUS options were due to the different amounts of trenching required.

The MIUS option I common trenching costs are as follows.

Neighborhood (no HVAC): Electrical distribution, potable water, and fire protection water. Cost: 36 800 feet of 5-foot-deep trenching, 2-1/2 feet wide at the bottom, at $3.45/ft.

Village center: Electrical distribution, potable water, fire protection water, and HVAC. Cost: 4750 feet of 6-foot-deep trenching, 8-1/2 feet wide at the bottom, at $4.30/ft.

Town center: Electrical distribution, potable water, fire protection water, and HVAC. Cost: 12 250 feet of 6-foot-deep trenching, 13-1/2 feet wide at the bottom, at $5.30/ft.

Wastewater lines were put into a separate trench for option I utilities. For the wastewater piping, a baseline system was devised, and the variations in pipe sizes were specified as additive or subtractive to this configuration. Tables E-68 to E-70 provide the results of the trenching costing and additional detail on these costs. The annual capital outlays for wastewater trenching are given in table E-69. Table E-70 illustrates the method used to arrive at the trenching costs for this subsystem.

MIUS OPTION II UTILITIES AND SERVICES

The MIUS option II concept provided for eight MIUS installations, one serving each village complex (a village center and three neighborhoods) and one serving the town center. Consistent with the conventional and MIUS option I concepts, water was obtained from a natural source located 15 miles from the community, and residual solid waste was disposed of by landfill outside the community. Disposal of excess treated wastewater was not costed. Domestic hot-water equipment and solid-waste disposal equipment was identical for both MIUS options and has been included with the option I data.

Because of the new-community concept with all the required infrastructure for supporting utilities distribution and because of the transient buildup plan of the community, separate identifiable MIUS costs were not used. Approximate costs for a MIUS serving a village center

and three neighborhoods have been compiled and are presented in table E-71.

MIUS Option II Electrical Power Subsystem

The MIUS option II electrical power subsystem for the community study consisted of eight separate powerplants, one serving each village complex (a village center and three neighborhoods) and one serving the town center. Each of these powerplants was installed in stages; that is, after the initial installation, additional engine-generator sets and transformer equipment were installed. Major items of supporting equipment to the powerplants were the electrical distribution subsystem and a central fuel storage and supply subsystem. Operator personnel costs for the electrical power subsystem, control subsystem, HVAC, and hot-water subsystem have been included under operating costs for the electrical power subsystem.

Capital costs.- A major cost item of the electrical power subsystem is the engine-generator sets with heat recovery equipment and local controls. Cost of these items was based on a composite of data and was taken at $175/kW installed for each of the 4415-kilowatt engine-generator sets. Other components of the electrical power subsystem were costed in detail from current cost data (refs. E-2, E-4, and E-5. The MIUS building costs have been included under a separate section as have the trenching costs for the electrical distribution subsystem. Trenching costs for electrical distribution are relatively small (approximately 20¢/ft).

Useful life.- A useful life of 32 years was assumed for all components of the subsystem with no salvage value at the end of this time. The 32-year useful life was determined for the conventional power system and was based on a cost weighted average of the components of generation, transmission, distribution, and general plant facilities. No comparable estimates were found for the useful life of diesel powerplants; however, data from reference E-17 indicate that some powerplants have been in operation for periods in excess of this. The useful-life value enters into the costs only in the unit cost values of mils/kWh and in the escalated and discounted cost values.

O&M costs.- Operator costs for the electrical power subsystem, control subsystem, HVAC, and hot-water subsystem are included under the O&M costs for electrical power and were based on the wages for a class V technician as reported by the Bureau of Labor for 1971 (ref. E-9). Fringe benefits were added and this estimate was escalated to 1973 costs. A

total of 64 operators are required for this system by the end of 1994. The no. 2 diesel fuel costs were taken at $1.02/10^6 Btu (approximately 14.3¢/gal delivered). Maintenance material and labor costs were based on data from reference 17. The 1970-1971 data were escalated to yield mid-1973 values. Table E-43, under option I costing, gives the maintenance data that were used.

The fuel distribution subsystem for MIUS option II was similar to that for option I. Results of the costing study and detailed information on the equipment for this subsystem are included in tables E-72 to E-76.

MIUS Option II Water Supply Subsystem

As for the conventional and the MIUS option I water supply costing, the supply was assumed to be from a natural source located 15 miles from the community. Raw water was pumped through a 42-inch-diameter cast iron pipeline to the community for local treatment. A single-supply pumping station was assumed with pumps being added as the needs of the community increased.

Eight treatment plants were assumed, each with a capacity of 1.675 x 10^6 gal/day. These plants were installed as the community requirements increased, providing a total capacity of 13.4 x 10^6 gal/day at the end of the community buildup period. Capital and O&M costs for the treatment plants were developed from comparative data obtained from numerous operating facilities and references E-11 to E-13.

The distribution system piping ranged in diameter from 42 to 1-1/2 inches. All distribution piping greater than 6 inches was assumed to be cast iron, and 6-inch and smaller piping was assumed to be plastic. A 100-year useful life was assumed for the cast iron and 50 years was assumed for the plastic piping according to the manufacturers' recommendation. A useful life of 30 years for all other equipment was assumed. No elevated storage was assumed for this system, and continuously operating pumps were used to provide head pressure for distribution. Fire protection water was assumed to be from treated wastewater stored in seven ponds and in the town center lakes. Tables E-77 to E-79 provide the costing results for the MIUS option II water supply subsystem and provide detailed cost data on the equipment.

MIUS Option II Hot-Water Subsystem

Identical hot-water subsystem equipment was assumed for option I and option II costing.

MIUS Option II Wastewater Subsystem

The MIUS option II wastewater subsystem is composed of a conventional gravity sewer collection system (with lift stations) and wastewater treatment plants. Effluent from the treatment plants was put into ponds located throughout the community to be used for irrigation and fire protection. A wastewater treatment plant with a capacity of 1.675×10^6 gal/day was included in each of the eight MIUS installations. Treatment plant capital and O&M costs were developed using references E-11 to E-13, E-16, E-19, E-20, and E-22 to E-24. A useful life of 30 years was assumed for the treatment plants. The conventional gravity collection sewer system included concrete sewer pipe in sizes from 8 to 24 inches, lift stations at each of the eight treatment plants as well as at other low points in the system, and manholes.

Tables E-80 to E-84 provide the results and additional data on costs of the MIUS option II wastewater subsystem. The original component data on the collection equipment were modified subsequent to the initial costing, and the modifications were specified, in part, as additions and deletions to the original configuration. These cost variations, in both cases, were absorbed in the first year and are titled in table E-82 as additive and subtractive deltas without further identification of the location of specific pieces of pipe added or deleted. The algebraic sum of the component values in table E-82 yields the correct annual capital cost data.

MIUS Option II HVAC Subsystem

The MIUS option II costing was accomplished in the same manner as the conventional equipment and option I costing. The town center equipment and parameters were the same for both options, and details of this equipment are given in table E-60. The major difference in the option I and option II concepts is in the village center/neighborhood complex equipment and in the variations in hot- and chilled-water distribution piping. Tables E-85 to E-88 provide the results of the option II HVAC costing and provide additional details on the equipment.

MIUS Option II Solid-Waste Subsystem

The MIUS option II solid-waste subsystem was identical to that of option I.

MIUS Option II Monitoring and Control Subsystem

The MIUS option II control subsystem was designed and costed, and details of this equipment are given in reference E-21. Tables E-89 and E-90 provide the costing results in a format consistent with other portions of the study.

MIUS Option II Buildings

The MIUS option II housing consists of a building in each village center/neighborhood complex and one building in the town center. Building specifications were as follows.

Building	Specifications
Town center:	
Size, ft	160 by 164 by 25 high
Floor area, ft^2	26 240
Volume, ft^3	656 000
Village center/ neighborhood:	
Size, ft	150 by 162 by 25 high
Floor area, ft^2	24 300
Volume, ft^3	607 500

All buildings were costed at $14.26/$ft^2$ floor area plus 75¢/ft^2 wall area for stone-finished, tilt-up concrete walls. These values were based on the 1973 Dodge Building Cost Guide (ref. E-3) for warehouse and office building construction of good quality. The Dodge values are unadjusted for regional location. (The type of construction for these costs is described in the section of this appendix entitled "MIUS Option I Buildings.") Tables E-91 and E-92 provide the MIUS building costs in a format consistent with other portions of this study.

MIUS Option II Utility Trenching

Several studies were conducted to compare the costs of various trenching combinations for the MIUS utilities; i.e., potable water, fire water distribution, HVAC, sewer, and electrical. (The studies are described in the section of this appendix entitled "MIUS Option I Utility Trenching.") Details and the average values used for the common trenching are as follows for the village center/neighborhood complex and the town center.

Neighborhood (no HVAC): Electrical distribution, potable water, and fire protection water. Cost: 35 250 feet of 5-foot-deep trench, 2-1/2 feet wide at the bottom, at $3.45/ft.

Village center: Electrical distribution, potable water, fire protection water, and HVAC. Cost: 11 610 feet of 6-foot-deep trench, 8-1/2 feet wide at the bottom, at $4.30/ft.

Town center: Electrical distribution, potable water, fire protection water, and HVAC. Cost: 12 250 feet of 6-foot-deep trench, 13-1/2 feet wide at the bottom, at $5.30/ft.

Wastewater trenching was costed separately, and, for both MIUS options, it was based on variations in pipe sizes and runs from the conventional system layout. The results of the trenching costing and additional details on the costs are presented in tables E-93 to E-95. Table E-94 gives the total annual wastewater trenching costs, and table E-95 illustrates the manner in which these costs were derived.

CONVENTIONAL ELECTRICAL POWER GENERATION COST COMPARISON FOR CENTRAL PLANTS USING DIFFERENT FUELS

The data presented in this section relate to central powerplants put into operation in the United States in recent years; they illustrate the wide variations in many capital and O&M cost parameters that affect the cost of electrical power. The data support the selection of the Homer City, Pa., coal-burning plant as a basis for costing conventional electrical power in that all costs related to that system are typical and do not bias the results presented as conventional power costs. Figures E-3 and E-4 summarize the variations in capital and O&M costs for central station powerplants. Tables E-96 and E-97 show the detailed data displayed in the figures. All data were taken from references E-25 and E-26.

CENTRAL HVAC COSTS FOR NEIGHBORHOOD SINGLE-FAMILY DWELLINGS

Subsequent to the design and cost evaluation of the MIUS options I and II community concepts, an evaluation was made for the equipment capital cost of providing hot and chilled water to the single-family dwelling units of the community for space-heating and air-conditioning. Each neighborhood of the community was planned as having 713 single-family dwelling units, each equipped with an individual 3-ton-capacity electrically powered air-conditioner for the conventional concept and for both MIUS concepts. In the cost analysis presented here, it was assumed that these units were replaced with a four-pipe two-valve heat exchanger system with the energy supply being from a central station chilled- and hot-water supply. The capital cost of this equipment was approximately twice that of the individual dwelling unit air-conditioners; however, over a period of 20 years, this outlay was largely offset by reduced maintenance cost.

Balanced energy loads were developed for the community as presented in the preceding sections of this document; therefore, no excess energy was available to support this concept. Tables E-98 to E-101 provide details on this study.

MIUS OPTION II VACUUM SEWER SYSTEM

A special study was conducted concerning the option II MIUS in which the conventional gravity-feed sewer system was replaced with a vacuum sewer system. The cost totals were obtained by using the information supplied by Colt Industries.[1] Two possible vacuum systems were considered; one using vacuum toilets and the second using conventional toilets. The two systems were considered so that the amount of water savings possible with a vacuum toilet system could be determined. Table E-102 shows the cost total for the vacuum systems according to Colt Industries specifications. The totals include an additional 9750 feet of 12-inch PVC pipe for the town center forced mains with vacuum toilets and 19 500 feet of 12-inch PVC pipe for the forced mains in the town center with the conventional toilet system. To maintain a consistency with the cost totals for other systems, the costs were deleted for the pipe connecting the street mains with the individual single-family dwellings in the neighborhoods.

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[1]Personal communication, Colt Industries, Beloit, Wis., 1973.

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TABLE E-1.- COST COMPARISON OF CONVENTIONAL AND MIUS UTILITIES AND SERVICES

Cost factor	Conventional	MIUS option I	MIUS option II
Total capital outlay, 1975-94, 1973 $	266 981 000	256 781 000	239 067 000
Total fuel cost, 1975-94, 1973 $[1]	155 660 000	100 609 000	100 328 000
Total operation and maintenance (O&M) cost, 1975-94, 1973 $[2]	162 235 000	189 379 000	157 944 000
Total outlay, 1975-94, 1973 $	584 876 000	546 769 000	497 339 000
Escalated and discounted outlay, 1975-94, 1975 $[3]	237 199 000	225 145 000	205 832 000
Escalated and discounted outlay, 1975-94, 1975 $[4]	398 151 000	326 422 000	306 666 000

[1]Diesel fuel for electrical power only.

[2]Excluding fuel for electrical power.

[3]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

[4]Fuel escalated at 15 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

TABLE E-2.- VARIATION IN CONVENTIONAL ELECTRICAL POWER COST WITH TYPE OF FUEL

Cost factor	Conventional diesel	Conventional fuel oil	Conventional coal	MIUS option I diesel	MIUS option II diesel
Service delivered, 1975-94, kWh	1.344×10^{10}	1.344×10^{10}	1.344×10^{10}	1.077×10^{10}	1.074×10^{10}
Capital outlay, 1975-94, 1973 $	118 310 000	118 310 000	118 310 000	68 205 000	66 452 000
Fuel, 1975-94, 1973 $	155 660 000	125 139 000	72 794 000	100 609 000	100 328 000
O&M, excluding fuel, 1975-94, 1973 $	50 809 000	50 809 000	50 809 000	65 812 000	64 047 000
Total outlay, 1975-94, 1973 $	324 779 000	294 258 000	241 913 000	234 626 000	230 827 000
Escalated and discounted outlay, 1975-94, 1975 $[1]	124 114 000	113 294 000	94 737 000	86 050 000	84 888 000
O&M cost/kWh, excluding fuel, 1973 mills	3.78	3.78	3.78	6.11	5.96
Total cost/kWh, 1973 mills	24.16	21.89	18.00	21.80	21.48
Total cost/kWh, less plant residual value, 1973 mills	18.31	16.04	12.15	17.61	17.42

[1]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

TABLE E-3.- SYSTEM, SUBSYSTEM COST COMPARISON[1]

[Total cash outlay 1975-94, 1973 $]

Cost factor	Conventional	MIUS Option I	MIUS Option II
Electrical power [2-3]	324 779 000	234 626 000	230 827 000
Water supply	63 219 000	42 721 000	44 704 000
Hot water	11 499 000	6 423 000	6 423 000
Wastewater	57 830 000	88 311 000	51 115 000
Heating, ventilation, and air-conditioning (HVAC)	91 385 000	97 606 000	101 571 000
Solid waste	36 164 000	36 391 000	36 391 000
Control system	(4)	26 218 000	12 867 000
MIUS buildings	(4)	4 004 000	3 628 000
Trenching	(4)	10 301 000	9 813 000
Totals	584 876 000	546 601 000	497 339 000

[1]Fuel costs are included in the costs for each system/subsystem.

[2]Diesel fuel.

[3]Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[4]These costs are included in the system costs.

TABLE E-4.- ELECTRICAL POWER COST COMPARISON[1]

Cost factor	Conventional	MIUS option I	MIUS option II
Service delivered, 1975-94, kWh	1.344×10^{10}	1.077×10^{10}	1.074×10^{10}
Capital outlay, 1975-94, 1973 $	118 310 000	68 205 000	66 452 000
Fuel, 1975-94, 1973 $[2]	155 660 000	100 609 000	100 328 000
O&M, excluding fuel, 1975-94, 1973 $	50 809 000	65 812 000	64 047 000
Total outlay, 1975-94, 1973 $	324 779 000	234 626 000	230 827 000
Escalated and discounted outlay, 1975-94, 1975 $[3]	124 111 000	86 050 000	84 888 000
O&M cost/kWh, excluding fuel, 1973 mills	3.78	6.11	5.96
Total cost/kWh, 1973 mills	18.31	17.61	17.42

[1]Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[2]Diesel fuel at $1.02/10^6$ Btu.

[3]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

TABLE E-5.- WATER SUPPLY COST COMPARISON[1]

Cost factor	Conventional	MIUS option I	MIUS option II
Service delivered, 1975-94, gal	101.135×10^9	53.480×10^9	53.480×10^9
Capital outlay, 1975-94, 1973 $	53 731 000	36 103 000	37 508 000
O&M costs, 1975-94, 1973 $	9 488 000	6 618 000	7 196 000
Total outlay, 1975-94, 1973 $	63 219 000	42 721 000	44 704 000
Escalated and discounted outlay, 1975-94, $[2]	38 831 000	29 371 000	30 265 000
Cost/1000 gal, 1973 ¢	19.4	26.7	29.0

[1]Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[2]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

TABLE E-6.- HOT-WATER COST COMPARISON[1]

Cost factor	Conventional	MIUS options I and II
Service delivered, 1975-94, gal	13.839×10^9	13.839×10^9
Capital outlay, 1975-94, 1973 $	6 076 000	4 211 000
O&M cost, 1975-94, 1973 $	5 423 000	2 212 000
Total outlay, 1975-94, 1973 $	11 499 000	6 423 000
Escalated and discounted outlay, 1975-94, 1975 $[2]	4 437 000	2 531 000
Cost/1000 gal, 1973 ¢[3]	39.2	16.0

[1]Maintenance labor, materials, and fuel; no electricity. Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[2]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

[3]Cost of water is included under water supply.

TABLE E-7.- WASTEWATER COST COMPARISON[1]

Cost factor	Conventional	MIUS option I	MIUS option II
Service delivered, 1975-94, gal	48.791x10⁹	48.791x10⁹	48.791x10⁹
Capital outlay, 1975-94, 1973 $	34 866 000	47 105 000	30 021 000
O&M costs, 1975-94, 1973 $	22 964 000	41 206 000	21 094 000
Total outlay, 1975-94, 1973 $	57 830 000	88 311 000	51 115 000
Escalated and discounted outlay, 1975-94, 1975 $[2]	24 847 000	35 992 000	22 168 000
Cost/1000 gal, 1973 ¢	68.5	116.9	62.7

[1]Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[2]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

TABLE E-8.- HVAC COST COMPARISON[1]

Cost factor	Conventional	MIUS option I	MIUS option II
Available capacity, 1994, tons	136 962	137 102	131 488
Capital outlay, 1975-94, 1973 $	44 271 000	65 876 000	71 379 000
O&M costs, 1975-94, 1973 $	[2]47 114 000	31 730 000	30 192 000
Total outlay, 1975-94, 1973 $	91 385 000	97 606 000	101 571 000
Escalated and discounted outlay, 1975-94, 1975 $[3]	33 158 000	41 317 000	41 796 000
Cost/ton of air-conditioning, 1973 $	324	480	542

[1]Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[2]Maintenance and fuel costs; no electrical cost.

[3]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

TABLE E-9.- SOLID-WASTE DISPOSAL COST COMPARISON[1]

Cost factor	Conventional	MIUS options I and II
Total service delivered, 1975-94, tons	1.530×10^6	1.530×10^6
Capital outlay, 1975-94, 1973 $	9 727 000	10 461 000
O&M costs, 1975-94, 1973 $	26 437 000	25 930 000
Total outlay, 1975-94, 1973 $	36 164 000	36 391 000
Escalated and discounted outlay, 1975-94, 1975 $[2]	11 812 000	11 992 000
Cost/ton, 1975-94, 1973 $	20.83	20.41
Value of energy recovered per ton, 1973 $[3]	0	7.68
Net cost per ton, 1973 $[3]	20.83	12.73

[1]Electrical power costs for the subsystems were not assigned to the subsystems but to "electrical power."

[2]Fuel escalated at 5 percent/yr, all other items at 3 percent/yr; discounted at 15 percent/yr to Jan. 1975.

[3]Credit taken for recovered energy at $1.02/10^6 Btu. This credit is realized in reduced fuel supplied to the MIUS and is separated here for illustration only.

TABLE E-10.- VARIATION IN ELECTRICAL POWER COST WITH FUEL-TYPE PLANT AND FUEL

Cost factor	Nuclear	Conventional Fuel oil/gas	Conventional Coal	MIUS option I diesel	MIUS option II diesel
Service delivered, 1975-94, kWh	1.344×10^{10}	1.344×10^{10}	1.344×10^{10}	1.077×10^{10}	1.074×10^{10}
Capital outlay, 1975-94, 1973 $ . . .	175 514 000	110 210 000	119 810 000	68 205 000	66 452 000
Fuel, 1975-94, 1973 $ . . .	29 250 000	[1]124 100 000	67 100 000	100 609 000	100 328 000
O&M, excluding fuel, 1975-94, 1973 $ . . .	49 200 000	45 200 000	50 400 000	65 812 000	64 047 000
Total outlay, 1975-94, 1973 $ . . .	253 964 000	279 510 000	237 310 000	234 626 000	230 827 000
O&M cost/kWh, excluding fuel, 1973 mills . . .	3.66	3.36	3.74	6.11	5.96
Total cost/kWh, 1973 mills[2]	18.86	20.76	19.63	21.80	21.45

[1]Fuel oil.

[2]No credit taken for equipment residual value at the end of 20 years. See system/subsystem comparison for those values.

TABLE E-11.- EXAMPLE OF DISCOUNTED CASH ANALYSIS PROGRAM OUTPUT

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 9/ 4/73

D. C. F. ANALYSIS FOR
CONVENTIONAL ELECTRICAL POWER (9/4/73)

Escalated values to the indicated year

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	5.841	0.204	0.665	6.710	6.597	6.597
1976	6.589	0.482	1.594	8.665	7.300	13.897
1977	11.449	0.888	2.994	15.331	11.209	25.106
1978	6.040	1.294	4.455	11.789	7.258	32.364
1979	4.179	1.524	5.339	11.042	5.802	38.166
1980	8.956	1.928	6.902	17.786	8.270	46.436
1981	7.274	2.223	8.102	17.599	7.026	53.462
1982	7.137	2.553	9.470	19.161	6.614	60.076
1983	10.835	3.188	12.090	26.112	7.885	67.961
1984	6.367	3.611	13.921	23.900	6.144	74.105
1985	4.990	3.905	15.368	24.263	5.376	79.481
1986	10.811	4.455	17.873	33.139	6.497	85.978
1987	10.833	4.873	19.933	35.639	6.056	92.034
1988	4.985	5.379	22.421	32.786	4.739	96.773
1989	12.456	5.987	25.436	43.878	5.622	102.395
1990	7.438	6.534	28.279	42.250	4.634	107.030
1991	7.150	6.937	30.621	44.708	4.254	111.284
1992	15.757	7.855	35.345	58.957	4.955	116.239
1993	10.082	8.472	38.874	57.428	4.141	120.380
1994	8.338	9.082	42.429	59.649	3.733	124.113

(Values indicated by arrows were used in summary data for presentation)

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	118.310	167.508	54.917
LESS RESID. VALUE	78.627	120.012	7.333
NET CAPITAL COSTS	39.683	47.496	47.584
COSTS FOR FUEL	155.660	342.111	55.183
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	50.809	81.374	14.014
TOTAL COSTS	246.152	470.981	116.781

CUMULATIVE SERVICE DELIVERED = 13.44180 x 10^9 KWH

AVERAGE UNIT COSTS (mills/kW) FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	8.802	12.462	4.086
LESS RESID. VALUE	5.849	8.928	0.546
NET CAPITAL COSTS	2.952	3.533	3.540
COSTS FOR FUEL	11.580	25.451	4.105
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	3.780	6.054	1.043
TOTAL COSTS	$\boxed{18.312}$	35.039	8.688

Use of this value reflects use of system useful life and accounts for system residual value at the end of the study period.

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OF POOR QUALITY

TABLE E-12.- COST DATA FOR CONVENTIONAL ELECTRICAL POWER SYSTEM

Item	Unit cost, 1973 $
Major capital cost items	
Powerplant[1] (replacement cost), $/kW	184.40
Transmission[2] (replacement cost), $/kW	61.00
General plant[2] (replacement cost), $/kW	14.70
Distribution system:	
500-MCM wire, installed, $/ft	3.58
1/0 ground wire, installed, $/ft	1.26
55-kVA transformers, installed, $/ea.	1120.00
88-kVA transformers, installed, $/ea.	1450.00
800-kW switchgear, installed, $/ea.	3460.00
O&M costs	
Fuel:	
No. 2 diesel, $/10^6 Btu	1.02
No. 6 fuel oil, $/10^6 Btu	.82
Coal, $/10^6 Btu	.477
Other:	
Generation, mills/kWh	1.21
Transmission, mills/kWh	.32
Distribution, mills/kWh	2.25

[1]Based on the Homer City, Pa., 1319-MW plant.
[2]Based on the East Central Power Region grid.

TABLE E-13.- CONVENTIONAL ELECTRICAL POWER SYSTEM

(DCF PROGRAM OUTPUT)

(a) Diesel fuel with escalation ratio of 5 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 9/ 4/73

D. C. F. ANALYSIS FOR
CONVENTIONAL ELECTRICAL POWER (9/4/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	5.841	0.204	0.665	6.710	6.597	6.597
1976	6.589	0.482	1.594	8.665	7.300	13.897
1977	11.449	0.888	2.994	15.331	11.209	25.106
1978	6.040	1.294	4.455	11.789	7.258	32.364
1979	4.179	1.524	5.339	11.042	5.802	38.166
1980	8.956	1.928	6.902	17.786	8.270	46.436
1981	7.274	2.223	8.102	17.599	7.026	53.462
1982	7.137	2.553	9.470	19.161	6.614	60.076
1983	10.835	3.188	12.090	26.112	7.885	67.961
1984	6.367	3.611	13.921	23.900	6.144	74.105
1985	4.990	3.905	15.368	24.263	5.376	79.481
1986	10.811	4.455	17.873	33.139	6.497	85.978
1987	10.833	4.873	19.933	35.639	6.056	92.034
1988	4.985	5.379	22.421	32.786	4.739	96.773
1989	12.456	5.987	25.436	43.878	5.622	102.395
1990	7.438	6.534	28.279	42.250	4.634	107.030
1991	7.150	6.937	30.621	44.708	4.254	111.284
1992	15.757	7.855	35.345	58.957	4.955	116.239
1993	10.082	8.472	38.874	57.428	4.141	120.380
1994	8.338	9.082	42.429	59.849	3.733	124.113

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	118.310	167.508	54.917
LESS RESID. VALUE	78.627	120.012	7.333
NET CAPITAL COSTS	39.683	47.496	47.584
COSTS FOR FUEL	155.660	342.111	55.183
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	50.809	81.374	14.014
TOTAL COSTS	246.152	470.981	116.781

CUMULATIVE SERVICE DELIVERED = 13.44180

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	8.802	12.462	4.086
LESS RESID. VALUE	5.849	8.928	0.546
NET CAPITAL COSTS	2.952	3.533	3.540
COSTS FOR FUEL	11.580	25.451	4.105
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	3.780	6.054	1.043
TOTAL COSTS	18.312	35.039	8.688

TABLE E-13.- Continued

(b) Diesel fuel with escalation ratio of 15 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.150
THIS RUN MADE 9/ 4/73

D. C. F. ANALYSIS FOR
CONVENTIONAL ELECTRICAL POWER (9/4/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	5.841	0.204	0.873	6.919	6.778	6.778
1976	6.589	0.482	2.294	9.365	7.829	14.607
1977	11.449	0.888	4.719	17.055	12.343	26.950
1978	6.040	1.294	7.689	15.023	9.108	36.058
1979	4.179	1.524	10.093	15.796	8.165	44.223
1980	8.956	1.928	14.291	25.174	11.464	55.688
1981	7.274	2.223	18.372	27.869	10.887	66.575
1982	7.137	2.553	23.521	33.211	11.207	77.782
1983	10.835	3.188	32.886	46.908	13.796	91.578
1984	6.367	3.[illegible]11	41.475	51.454	12.955	104.533
1985	4.990	3.905	50.144	59.039	12.851	117.384
1986	10.811	4.455	63.872	79.138	15.095	132.478
1987	10.833	4.873	78.018	93.725	15.497	147.975
1988	4.985	5.379	96.116	106.480	15.154	163.130
1989	12.456	5.987	119.424	137.867	17.173	180.302
1990	7.438	6.534	145.417	159.388	17.152	197.454
1991	7.150	6.937	172.455	186.542	17.434	214.889
1992	15.757	7.855	218.022	241.634	19.716	234.605
1993	10.082	8.472	262.626	281.181	19.864	254.468
1994	8.338	9.082	313.944	331.364	20.323	274.791

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	118.310	167.508	54.917
LESS RESID. VALUE	78.627	120.012	7.333
NET CAPITAL COSTS	39.683	47.496	47.584
COSTS FOR FUEL	155.660	1676.253	205.861
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	50.809	81.374	14.014
TOTAL COSTS	246.152	1805.123	267.459

CUMULATIVE SERVICE DELIVERED = 13.44180

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	8.802	12.462	4.086
LESS RESID. VALUE	5.849	8.928	0.546
NET CAPITAL COSTS	2.952	3.533	3.540
COSTS FOR FUEL	11.580	124.704	15.315
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	3.780	6.054	1.043
TOTAL COSTS	18.312	134.292	19.898

TABLE E-13.- Continued

(c) Fuel oil at 82¢ per million Btu

FUEL COST IS 82.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 9/ 4/73

D. C. F. ANALYSIS FOR
CONVENTIONAL ELECTRICAL POWER (9/4/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	5.841	0.204	0.534	6.580	6.484	6.484
1976	6.589	0.482	1.282	8.353	7.063	13.547
1977	11.449	0.888	2.407	14.744	10.823	24.370
1978	6.040	1.294	3.581	10.915	6.759	31.129
1979	4.179	1.524	4.292	9.995	5.281	36.410
1980	8.956	1.928	5.549	16.433	7.685	44.095
1981	7.274	2.223	6.513	16.010	6.429	50.524
1982	7.137	2.553	7.613	17.304	6.007	56.531
1983	10.835	3.188	9.719	23.742	7.211	63.742
1984	6.367	3.611	11.192	21.171	5.469	69.211
1985	4.990	3.905	12.354	21.249	4.728	73.939
1986	10.811	4.455	14.368	29.634	5.842	79.781
1987	10.833	4.873	16.024	31.731	5.421	85.203
1988	4.985	5.379	18.025	28.389	4.118	89.321
1989	12.456	5.987	20.448	38.891	5.009	94.330
1990	7.438	6.534	22.734	36.706	4.042	98.371
1991	7.150	6.937	24.617	38.704	3.696	102.068
1992	15.757	7.855	28.415	52.026	4.395	106.463
1993	10.082	8.472	31.252	49.805	3.606	110.068
1994	8.338	9.082	34.110	51.530	3.225	113.293

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	118.310	167.508	54.917
LESS RESID. VALUE	78.627	120.0120	7.333
NET CAPITAL COSTS	39.683	47.496	47.584
COSTS FOR FUEL	125.139	275.030	44.363
OTHER OP. COSTS	0.000	0.00	0.000
MAINTENANCE COSTS	50.809	81.374	14.014
TOTAL COSTS	215.671	403.900	105.961

CUMULATIVE SERVICE DELIVERED = 13.44180

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	8.802	12.462	4.086
LESS RESID. VALUE	5.849	8.928	0.546
NET CAPITAL COSTS	2.952	3.533	3.540
COSTS FOR FUEL	9.310	20.461	3.300
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	3.780	6.054	1.043
TOTAL COSTS	16.042	30.048	7.883

TABLE E-13.- Concluded

(d) Coal at 47.7¢ per million Btu

FUEL COST IS 47.70 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 9/ 4/73

D. C. F. ANALYSIS FOR
CONVENTIONAL ELECTRICAL POWER (9/4/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	5.841	0.204	0.311	6.357	6.289	6.289
1976	6.589	0.482	0.746	7.816	6.658	12.947
1977	11.449	0.888	1.400	13.737	10.161	23.18
1978	6.040	1.294	2.083	9.417	5.902	29.011
1979	4.179	1.524	2.497	8.200	4.388	33.399
1980	8.956	1.928	3.228	14.112	6.682	40.081
1981	7.274	2.223	3.789	13.286	5.405	45.486
1982	7.137	2.553	4.429	14.119	4.966	50.451
1983	10.835	3.188	5.654	19.676	6.055	56.507
1984	6.367	3.611	6.510	16.489	4.312	60.819
1985	4.990	3.905	7.187	16.082	3.618	64.436
1986	10.811	4.455	8.358	23.624	4.719	69.155
1987	10.833	4.873	9.321	25.028	4.332	73.487
1988	4.985	5.379	10.485	20.850	3.052	76.539
1989	12.456	5.987	11.895	30.337	3.958	80.497
1990	7.438	6.534	13.224	27.196	3.026	83.522
1991	7.150	6.937	14.320	28.407	2.739	86.262
1992	15.757	7.855	16.529	40.141	3.435	89.696
1993	10.082	8.472	18.179	36.733	2.687	92.384
1994	8.338	9.082	19.842	37.262	2.353	94.737

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	118.310	167.508	54.917
LESS RESID. VALUE	78.627	120.012	7.333
NET CAPITAL COSTS	39.683	47.496	47.584
COSTS FOR FUEL	72.794	159.987	25.806
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	50.809	81.374	14.014
TOTAL COSTS	163.286	288.857	87.404

CUMULATIVE SERVICE DELIVERED = 13.44180

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	8.802	12.462	4.086
LESS RESID. VALUE	5.849	8.928	0.546
NET CAPITAL COSTS	2.952	3.533	3.540
COSTS FOR FUEL	5.415	11.902	1.920
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	3.780	6.054	1.043
TOTAL COSTS	12.148	21.489	6.502

TABLE E-14.- CONVENTIONAL ELECTRICAL POWER SYSTEM

(INPUTS TO DCF PROGRAM)

[Purchased capacity based on 6 percent above 2-sigma peak kilowatt requirement]

Year	Capital, 1973 $ (1)	Fuel, Btu (2)	Other O&M, 1973 $ (3)	Service delivered, kWh
1975	5.506×10^{6}	56.3×10^{10}	0.187×10^{6}	0.0496×10^{9}
1976	6.030	128.6	.428	.1132
1977	10.172	230.0	.766	.2026
1978	5.210	325.9	1.084	.2868
1979	3.500	372	1.239	.3279
1980	7.282	458	1.522	.4030
1981	5.742	512	1.704	.4510
1982	5.470	570	1.900	.5025
1983	8.062	693	2.303	.6100
1984	4.600	760	2.533	.6700
1985	3.500	799	2.659	.7041
1986	7.362	885	2.945	.7795
1987	7.162	940	3.128	.8274
1988	3.200	1007	3.352	.8865
1989	7.762	1088	3.622	.9587
1990	4.500	1152	3.838	1.0149
1991	4.200	1188	3.956	1.0471
1992	8.986	1306	4.349	1.1500
1993	5.582	1368	4.554	1.2049
1994	4.482	1422	4.740	1.2521

[1]A useful life of 32 years was assumed for all electrical equipment.

[2]Based on 11 360 Btu/kWh.

[3]Based on 3.78 mills/kWh.

TABLE E-15.- CONVENTIONAL ELECTRICAL POWER SYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description [1]	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Powerplant	4.62×10^6	
	One-third of distribution, village A, neighborhoods 1, 2, 3	.886	5.506×10^6
1976	Powerplant	5.11	
	One-third of distribution, village A, neighborhoods 1, 2, 3	.882	
	Town center	.038	6.030
1977	Powerplant	8.59	
	One-third of distribution, village A, neighborhoods 1, 2, 3	.882	
	One-fourth of distribution, village B, neighborhoods 1, 2, 3	.662	
	Town center	.038	10.172
1978	Powerplant	4.51	
	One-fourth of distribution, village B, neighborhoods 1, 2, 3	.662	
	Town center	.038	5.210
1979	Powerplant	2.80	
	One-fourth of distribution, village B, neighborhoods 1, 2, 3	.662	
	Town center	.038	3.500
1980	Powerplant	5.92	
	One-fourth of distribution, village B, neighborhoods 1, 2, 3	.662	
	One-fourth of distribution, village C, neighborhoods 1, 2, 3	.662	
	Town center	.038	7.282
1981	Powerplant	5.08	
	One-fourth of distribution, village C, neighborhoods 1, 2, 3	.662	5.742
1982	Powerplant	4.77	
	One-fourth of distribution, village C, neighborhoods 1, 2, 3	.662	
	Town center	.038	5.470
1983	Powerplant	6.70	
	One-fourth of distribution, village C, neighborhoods 1, 2, 3	.662	
	One-fourth of distribution, village D, neighborhoods 1, 2, 3	.662	
	Town center	.038	8.062
1984	Powerplant	3.90	
	One-fourth of distribution, village D, neighborhoods 1, 2, 3	.662	
	Town center	.038	4.600

[1]The entry "powerplant" includes generation, transmission, and general plant.

Table E-15.- Concluded

Year	Description (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
1985	Powerplant	2.80×10^6	
	One-fourth of distribution, village D, neighborhoods 1, 2, 3	.662	
	Town center	.038	3.500×10^6
1986	Powerplant	6.00	
	One-fourth of distribution, village E, neighborhoods 1, 2, 3	.662	
	One-fourth of distribution, village D, neighborhoods 1, 2, 3	.662	
	Town center	.038	7.362
1987	Powerplant	5.50	
	One-fourth of distribution, village E, neighborhoods 1, 2, 3	.662	6.162
1988	Powerplant	2.50	
	One-fourth of distribution, village E, neighborhoods 1, 2, 3	.662	
	Town center	.038	3.200
1989	Powerplant	6.40	
	One-fourth of distribution, village E, neighborhoods 1, 2, 3	.662	
	One-fourth of distribution, village F, neighborhoods 1, 2, 3	.662	
	Town center	.038	7.762
1990	Powerplant	3.80	
	One-fourth of distribution, village F, neighborhoods 1, 2, 3	.662	
	Town center	.038	4.500
1991	Powerplant	3.50	
	One-fourth of distribution, village F, neighborhoods 1, 2, 3	.662	
	Town center	.038	4.200
1992	Powerplant	7.40	
	One-fourth of distribution, village F, neighborhoods 1, 2, 3	.662	
	One-third of distribution, village G, neighborhoods 1, 2, 3	.886	
	Town center	.038	8.986
1993	Powerplant	4.70	
	One-third of distribution, village G, neighborhoods 1, 2, 3	.882	5.582
1994	Powerplant	3.60	
	One-third of distribution, village G, neighborhoods 1, 2, 3	.882	4.482

[1]The entry "powerplant" includes generation, transmission, and general plant.

TABLE E-16.- CONVENTIONAL ELECTRICAL POWER DISTRIBUTION

(COMPONENT CAPITAL COSTS)

Village complex (village center plus three neighborhoods) distribution system definition:	
500-MCM single-run wire, ft	128 250 (106 850 + 20 percent)
1/0 single-run ground wire, ft	128 250
50-kW transformers, quantity	832
800-kW switchgears, quantity	52
One-third village plus one-third of three neighborhoods, cost:	
500-MCM single-run wire, 128 250 ft at $3.58/ft, cost	$\$0.459 \times 10^6$
1/0 single-run ground wire, 42 750 ft at $1.26/ft, cost	.054
50-kW transformers, 277 at $1120 ea, cost	.310
800-kW switchgears, 17 at $3460 ea, cost	.059
Total	$\$0.882 \times 10^6$
One-fourth of village plus one-fourth of three neighborhoods, cost	$\$0.662 \times 10^6$ (.882(3/4))
Town center distribution system definition (15 yr buildup):	
400-MCM single-run wire, ft	21 300 (18 500 + 15 percent)
1/0 single-run ground wire, ft	21 300
6000-kW transformers, quantity	7
800-kW switchgears, quantity	52
Town center distribution system yearly costs:	
400-MCM single-run wire, 4260 ft at $3.05/ft, cost/yr	$13 000
1/0 single-run ground wire, 1420 ft at $1.26/ft, cost/yr	1 790
6000-kW transformers, cost/yr[1]	11 200
800-kW switchgears, cost/yr[2]	12 000
Cost/yr for 15 yr	$38 000

[1]Transformers: 7 at $24 000 ea; 7($24 000)(1/15) = $11 200/yr.
[2]Switchgears: 52 at $3460 ea; 52($3460)(1/15) = $12 000/yr.

TABLE E-17.- CONVENTIONAL WATER SUPPLY SYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 11/29/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL WATER SUPPLY - 11/29/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	23.598	0.024	0.000	23.622	23.619	23.619
1976	0.730	0.077	0.000	0.807	0.693	24.312
1977	3.212	0.153	0.000	3.365	2.530	26.841
1978	0.774	0.222	0.000	0.997	0.636	27.478
1979	0.798	0.272	0.000	1.069	0.591	28.069
1980	3.885	0.342	0.000	4.227	2.079	30.148
1981	0.846	0.420	0.000	1.266	0.524	30.672
1982	0.872	0.478	0.000	1.350	0.484	31.156
1983	3.805	0.563	0.000	4.368	1.404	32.560
1984	0.958	0.654	0.000	1.612	0.434	32.994
1985	0.952	0.725	0.000	1.678	0.391	33.385
1986	5.968	0.818	0.000	6.786	1.436	34.821
1987	5.825	0.922	0.000	6.747	1.239	36.060
1988	1.041	1.006	0.000	2.047	0.311	36.371
1989	4.816	1.121	0.000	5.936	0.818	37.189
1990	1.104	1.238	0.000	2.342	0.268	37.457
1991	1.137	1.333	0.000	2.470	0.245	37.703
1992	6.467	1.479	0.000	7.946	0.720	38.423
1993	1.206	1.639	0.000	2.845	0.213	38.636
1994	1.243	1.772	0.000	3.015	0.196	38.831

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	53.731	69.237	36.267
LESS RESID. VALUE	43.605	58.868	3.597
NET CAPITAL CØSTS	10.126	10.369	32.670
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.00C	0.000
MAINTENANCE CØSTS	9.488	15.261	2.564
TØTAL CØSTS	19.614	25.630	35.235

CUMULATIVE SERVICE DELIVERED = 101.13500

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.531	0.685	0.359
LESS RESID. VALUE	0.431	0.582	0.036
NET CAPITAL CØSTS	0.100	0.103	0.323
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.094	0.151	0.025
TØTAL CØSTS	0.194	0.253	0.348

C.5

TABLE E-18.- CONVENTIONAL WATER SUPPLY SYSTEM (INPUTS TO DCF PROGRAM)

Year	Capital, 1973 $	Useful life, yr	O&M, 1973 $	Service delivered, gal
1975	20.195×10^6 .850 1.198	100 40 30	0.0222×10^6	0.237×10^9
1976	.668	100	.0685	.730
1977	1.722 1.132	100 30	.1320	1.405
1978	.688	100	.1863	1.988
1979	.688	100	.2210	2.355
1980	2.027 1.132	100 30	.270	2.880
1981	.668	100	.322	3.430
1982	.668	100	.356	3.800
1983	1.699 1.132	100 30	.407	4.340
1984	.668 .025	100 30	.459	4.890
1985	.668	100	.494	5.260
1986	2.932 1.132	100 30	.541	5.760
1987	.850 .013 2.990	40 30 100	.592	6.310
1988	.668	100	.627	6.690
1989	1.869 1.132	100 30	.678	7.230
1990	.668	100	.727	7.750
1991	.668	100	.760	8.100
1992	2.556 1.132	100 30	.819	8.730
1993	.668	100	.881	9.390
1994	.668	100	.925	9.860

TABLE E-19.- CONVENTIONAL WATER SUPPLY SYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	79 200 ft of 42-in. cast iron pipe at $170.57/ft	13 500 000	
	Treatment plant	1 132 000	
	Source pumps, 2 ea. plus building	53 400	
	Water tank, 3.5 x 10^6 gal	850 000	
	9000 ft of 42-in. pipe at $170.57/ft	1 535 000	
	19 000 ft of 36-in. pipe at $136.58/ft	2 595 000	
	12 000 ft of 30-in. pipe at $98.27/ft	1 180 000	
	3600 ft of 20-in. pipe at $51.00/ft	183 600	
	6800 ft of 16-in. pipe at $36.84/ft	250 500	
	1600 ft of 14-in. pipe at $30.68/ft	49 100	
	400 ft of 8-in. pipe at $13.50/ft	5 400	
	Village A	231 200	
	One-third of village A, neighborhoods 1, 2, 3	668 400	
	Boost pump, tank no. 1	12 500	22 246 100
1976	One-third of village A, neighborhoods 1, 2, 3	668 400	668 400
1977	One-third of village A, neighborhoods 1, 2, 3	668 400	
	4800 ft of 30-in. pipe at $98.27/ft	471 696	
	3700 ft of 20-in. pipe at $51.00/ft	188 700	
	2200 ft of 14-in. pipe at $30.68/ft	67 496	
	1700 ft of 12-in. pipe at $23.35/ft	39 695	
	2600 ft of 10-in. pipe at $17.55/ft	45 630	
	700 ft of 8-in. pipe at $13.50/ft	9 450	
	Village B	231 200	
	Treatment plant addition	1 132 000	2 854 267
1978	One-third of village B, neighborhoods 1, 2, 3	668 400	668 400
1979	One-third of village B, neighborhoods 1, 2, 3	668 400	668 400
1980	One-third of village B, neighborhoods 1, 2, 3	668 400	
	Village C	231 200	
	9600 ft of 30-in. pipe at $98.27/ft	943 392	
	3600 ft of 20-in. pipe at $51.00/ft	183 600	
	Treatment plant	1 132 000	3 158 592
1981	One-third of village C, neighborhoods 1, 2, 3	668 400	668 400
1982	One-third of village C, neighborhoods 1, 2, 3	668 400	668 400
1983	One-third of village C, neighborhoods 1, 2, 3	668 400	
	Village D	231 200	
	2400 ft of 36-in. pipe at $136.58/ft	327 792	
	4800 ft of 30-in. pipe at $98.27/ft	471 696	
	Treatment plant addition	1 132 000	2 831 088
1984	One-third of village D, neighborhoods 1, 2, 3	668 400	
	Supply pumps	24 500	692 900
1985	One-third of village D, neighborhoods 1, 2, 3	668 400	668 400
1986	One-third of village D, neighborhoods 1, 2, 3	668 400	
	Village E	231 200	
	4900 ft of 36-in. pipe at $136.58/ft	669 242	
	12 000 ft of 30-in. pipe at $98.27/ft	1 179 240	
	3600 ft of 20-in. pipe at $51.00/ft	183 600	
	Treatment plant	1 132 000	4 063 682
1987	One-third of village E, neighborhoods 1, 2, 3	668 400	
	17 000 ft of 36-in. pipe at $136.58/ft	2 321 860	
	Water tank no. 2	850 000	
	Boost pump	12 500	3 852 760

TABLE E-19.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1988	One-third of village E, neighborhoods 1, 2, 3	668 400	668 400
1989	One-third of village E, neighborhoods 1, 2, 3	668 400	
	Village F	231 200	
	Treatment plant	1 132 000	
	4700 ft of 36-in. pipe at $136.58/ft	641 926	
	2400 ft of 30-in. pipe at $98.27/ft	235 848	
	1800 ft of 20-in. pipe at $51.00/ft	91 800	3 001 174
1990	One-third of village F, neighborhoods 1, 2, 3	668 400	668 400
1991	One-third of village F, neighborhoods 1, 2, 3	668 400	668 400
1992	One-third of village F, neighborhoods 1, 2, 3	668 400	
	Village G	231 200	
	One-third of village G, neighborhoods 1, 2, 3	668 400	
	Treatment plant addition	1 132 000	
	7200 ft of 30-in. pipe at $98.27/ft	707 544	
	1800 ft of 20-in. pipe at $51.00/ft	91 800	3 499 344
1993	One-third of village G, neighborhoods 1, 2, 3	668 400	668 400
1994	One-third of village G, neighborhoods 1, 2, 3	668 400	668 400

TABLE E-20.- CONVENTIONAL WATER SUPPLY SYSTEM

(COMPONENT CAPITAL AND O&M COSTS)

Item	Unit cost, 1973 $	Useful life, yr
Major capital cost items		
Treatment plant, seven 4×10^6 gal/day stages, $/stage	1 132 000	30
Cast iron pipe, 8- to 42-inch, installed, $/ft	13.50 to 170.50	100
Water tanks, 3.5×10^6 gallon capacity, $	850 000	40
Tank boost pumps, $	12 500	30
Supply pumps and housing (2 separate installations), $	53 400	30
O&M costs		
Treatment plant:		
Electricity, kWh/1000 gal	[1]0.89	[2]NA
Chemicals (clarification, carbon, chlorine), ¢/1000 gal	2.73	NA
O&M labor, ¢/1000 gal	3.93	NA
Miscellaneous, ¢/1000 gal	1.74	NA
Distribution system maintenance, ¢/1000 gal . . .	.98	NA
Supply pumping power, kWh/1000 gal	[1].71	NA

[1]Electrical power cost was included with the electrical power system costs.

[2]Not applicable.

TABLE E-21.- CONVENTIONAL HOT-WATER SYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 12/ 4/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL HØT WATER - 12/4/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V. CØST
1975	0.284	0.015	0.007	0.306	0.303	0.303
1976	0.343	0.033	0.022	0.398	0.339	0.642
1977	0.544	0.062	0.039	0.644	0.477	1.119
1978	0.259	0.077	0.053	0.389	0.245	1.364
1979	0.293	0.094	0.073	0.460	0.251	1.615
1980	0.536	0.125	0.098	0.759	0.363	1.977
1981	0.278	0.143	0.120	0.541	0.219	2.196
1982	0.287	0.162	0.138	0.587	0.206	2.402
1983	0.588	0.197	0.171	0.956	0.297	2.699
1984	0.309	0.219	0.197	0.725	0.191	2.890
1985	0.295	0.241	0.219	0.755	0.172	3.062
1986	0.638	0.281	0.256	1.174	0.237	3.299
1987	0.328	0.306	0.286	0.920	0.157	3.457
1988	0.332	0.332	0.315	0.980	0.146	3.602
1989	0.699	0.378	0.364	1.441	0.190	3.792
1990	0.369	0.408	0.405	1.182	0.132	3.924
1991	0.378	0.440	0.449	1.267	0.123	4.047
1992	0.872	0.498	0.512	1.882	0.163	4.210
1993	0.513	0.540	0.562	1.615	0.119	4.329
1994	0.510	0.582	0.609	1.701	0.109	4.437

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.076	8.654	2.773
LESS RESID. VALUE	6.076	8.913	0.545
NET CAPITAL CØSTS	0.000	-0.260	2.229
CØSTS FØR FUEL	2.220	4.897	0.779
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	3.203	5.131	0.885
TØTAL CØSTS	5.423	9.768	3.893

CUMULATIVE SERVICE DELIVERED = 13.83870

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.439	0.625	0.200
LESS RESID. VALUE	0.439	0.644	0.039
NET CAPITAL CØSTS	0.000	-0.019	0.161
CØSTS FØR FUEL	0.160	0.354	0.056
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.231	0.371	0.064
TØTAL CØSTS	0.392	0.706	0.281

TABLE E-21.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 12/ 4/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL HØT WATER - 12/4/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V. CØST
1975	0.284	0.015	0.009	0.308	0.305	0.305
1976	0.343	0.033	0.032	0.407	0.347	0.651
1977	0.544	0.062	0.061	0.666	0.492	1.143
1978	0.259	0.077	0.091	0.427	0.267	1.410
1979	0.293	0.094	0.139	0.526	0.283	1.693
1980	0.536	0.125	0.203	0.864	0.408	2.101
1981	0.278	0.143	0.273	0.694	0.277	2.378
1982	0.287	0.162	0.343	0.792	0.273	2.651
1983	0.588	0.197	0.466	1.251	0.381	3.031
1984	0.309	0.219	0.588	1.116	0.287	3.319
1985	0.295	0.241	0.714	1.250	0.278	3.597
1986	0.638	0.281	0.914	1.832	0.360	3.957
1987	0.328	0.306	1.121	1.754	0.293	4.250
1988	0.332	0.332	1.352	2.016	0.292	4.542
1989	0.699	0.378	1.710	2.787	0.355	4.898
1990	0.369	0.408	2.082	2.859	0.311	5.209
1991	0.378	0.440	2.528	3.346	0.316	5.525
1992	0.872	0.498	3.155	4.525	0.376	5.902
1993	0.513	0.540	3.797	4.850	0.346	6.248
1994	0.510	0.582	4.508	5.600	0.347	6.595

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.076	8.654	2.773
LESS RESID. VALUE	6.076	8.913	0.545
NET CAPITAL CØSTS	0.000	-0.260	2.229
CØSTS FØR FUEL	2.220	24.087	2.936
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	3.203	5.131	0.885
TØTAL CØSTS	5.423	28.959	6.050

CUMULATIVE SERVICE DELIVERED = 13.83870

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.439	0.625	0.200
LESS RESID. VALUE	0.439	0.644	0.039
NET CAPITAL CØSTS	0.000	-0.019	0.161
CØSTS FØR FUEL	0.160	1.741	0.212
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.231	0.371	0.064
TØTAL CØSTS	0.392	2.093	0.437

TABLE E-22.- CONVENTIONAL HOT-WATER SYSTEM (INPUTS TO THE DCF PROGRAM)

YEAR	CAPITAL (1973 $ x 10^{-6})	FUEL (BTU x 10^{-9})	ELECTRICITY (KWH x 10^{-6})	OTHER O-AND-M INCLUDING LABOR (1973 $ x 10^{-6})	MAN YEARS (O-AND-M)	SERVICE DEL. GAL x 10^{-3}
1975	.2676	5.95	.000	.0134	.00	57876.
1976	.3137	17.74	.000	.0291	.00	124224.
1977	.4830	29.77	.000	.0532	.00	226621.
1978	.2234	38.77	.000	.0644	.00	275717.
1979	.2451	51.20	.000	.0766	.00	329170.
1980	.4355	65.19	.000	.0984	.00	422871.
1981	.2197	76.11	.000	.1094	.00	473457.
1982	.2198	83.18	.000	.1204	.00	519969.
1983	.4377	98.18	.000	.1423	.00	613962.
1984	.2232	107.73	.000	.1534	.00	663215.
1985	.2071	113.82	.000	.1638	.00	708758.
1986	.4345	126.60	.000	.1855	.00	800442.
1987	.2166	135.03	.000	.1963	.00	849122.
1988	.2132	141.66	.000	.2070	.00	895059.
1989	.4355	155.87	.000	.2288	.00	988359.
1990	.2232	164.94	.000	.2399	.00	1037613.
1991	.2219	174.13	.000	.2510	.00	1087297.
1992	.4971	189.02	.000	.2759	.00	1194542.
1993	.2842	197.79	.000	.2901	.00	1256189.
1994	.2742	204.17	.000	.3038	.00	1314640.

(a) Input data array

	BUILDING	ELECTRICAL RATE $/KWH	FUEL RATE $/MBTU	LABOR RATE $/MAN-YEAR
1	SINGLE FAMILY	.0000	1.0200	10100.0
2	TOWN HOUSE	.0000	1.0200	10100.0
3	GARDEN APARTMENT	.0000	1.0200	10100.0
4	ELEMENTRY SCHOOL	.0000	1.0200	10100.0
5	VILL HI RISE APT	.0000	1.0200	10100.0
6	MIDDLE SCHOOL	.0000	1.0200	10100.0
7	HIGH SCHOOL	.0000	1.0200	10100.0
8	VILL OFFICE BLDG	.0000	1.0200	10100.0
9	RECREATION CENTR	.0000	1.0200	10100.0
10	SHOPPING CENTER	.0000	1.0200	10100.0
11	COLLEGE	.0000	1.0200	10100.0
12	SHOPPING MALL	.0000	1.0200	10100.0
13	MALL RESTAURANT	.0000	.0000	10100.0
14	OFFICE BUILDING	.0000	1.0200	10100.0
15	LO RISE INN	.0000	1.0200	10100.0
16	HI RISE INN	.0000	1.0200	10100.0
17	INN RESTAURANT	.0000	1.0200	10100.0
18	HOSPITAL	.0000	1.0200	10100.0
19	HI RISE APARTMNT	.0000	1.0200	10100.0

	BUILDING	A/C CAPACITY TONS	A/C POWER KW	ANNUAL HEAT-MBTU	ELECTRICITY KWH X .0001	PERSONNEL MEN	CAPITAL $ X.001	MAINTAINENCE $ X.01
1	SINGLE FAMILY	41.90	.00	.00	.0000	.00	.197	.0985
2	TOWN HOUSE	41.90	.00	.00	.0000	.00	.197	.0985
3	GARDEN APARTMENT	20.00	.00	.00	.0000	.00	.121	.0605
4	ELEMENTRY SCHOOL	452.60	.00	338.00	.0000	.00	6.592	3.2960
5	VILL HI RISE APT	3746.70	.00	2805.00	.0000	.00	8.761	4.3805
6	MIDDLE SCHOOL	3022.90	.00	2263.00	.0000	.00	9.746	4.8730
7	HIGH SCHOOL	3022.90	.00	2263.00	.0000	.00	9.746	4.8730
8	VILL OFFICE BLDG	574.87	.00	431.00	.0000	.00	6.592	3.2960
9	RECREATION CENTR	408.80	.00	306.00	.0000	.00	6.592	3.2960
10	SHOPPING CENTER	172.20	.00	128.00	.0000	.00	.228	.1140
11	COLLEGE	180.00	.00	135.00	.0000	.00	.495	.2475
12	SHOPPING MALL	574.00	.00	860.00	.0000	.00	6.592	3.2960
13	MALL RESTAURANT	.00	.00	.00	.0000	.00	6.592	3.2900
14	OFFICE BUILDING	574.80	.00	688.00	.0000	.00	6.592	3.2960
15	LO RISE INN	3890.00	.00	2160.00	.0000	.00	8.761	4.3800
16	HI RISE INN	2882.00	.00	2916.00	.0000	.00	9.746	4.8730
17	INN RESTAURANT	.00	.00	.00	.0000	.00	7.860	3.9300
18	HOSPITAL	10723.70	.00	9030.00	.0000	.00	19.492	9.7460
19	HI RISE APARTMNT	3746.70	.00	2805.00	.0000	.00	8.761	4.3005

TABLE E-23.- Continued

(b) Input schedule array

1	713.00	713.00	1247.00	534.00	534.00	1071.00	534.00	534.00
	1071.00	534.00	534.00	1071.00	534.00	534.00	1071.00	534.00
	534.00	1247.00	713.00	713.00				
2	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
3	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
4	1.00	1.00	2.00	.00	1.00	2.00	.00	1.00
	2.00	.00	1.00	2.00	.00	1.00	2.00	.00
	1.00	2.00	1.00	1.00				
5	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	4.00	2.00	2.00				
6	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
7	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
8	.00	1.00	1.00	.00	1.00	1.00	.00	1.00
	1.00	.00	.00	1.00	1.00	.00	1.00	1.00
	1.00	1.00	1.00	1.00				
9	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
10	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
11	.00	.00	.00	1.00	.00	.00	.00	.00
	.00	.00	1.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
12	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	1.00	.00	.00	.00	.00	1.00	.00
	.00	.00	.00	.00				
13	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
14	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	.00	.00	.00				
15	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
16	.00	.00	1.00	.00	.00	.00	1.00	.00
	1.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
17	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
18	.00	.00	.00	.00	.00	.50	.00	.00
	.00	.00	.00	.00	.00	.00	.50	.00
	.00	.00	.00	.00				
19	.00	.00	.00	.00	1.00	.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	.00	.00
	1.00	.00	.00	.00				

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TABLE E-23.- Continued

(c) Total annual capital expenditures ($\$ \times 10^{-5}$)

BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1 SINGLE FAMILY	1.4096	1.4096	2.4566	1.0520	1.0520	2.1099	1.0520	1.0520	2.1099	1.0520
2 TOWN HOUSE	.6383	.6383	1.1170	.4787	.4787	.9574	.4787	.4787	.9574	.4787
3 GARDEN APARTMENT	.3920	.3920	.6861	.2940	.2940	.5881	.2940	.2940	.5881	.2940
4 ELEMENTRY SCHOOL	.0659	.0659	.1318	.0000	.0659	.1318	.0000	.0659	.1318	.0000
5 VILL HI RISE APT	.1752	.1752	.1752	.1752	.1752	.1752	.1752	.1752	.1752	.1752
6 MIDDLE SCHOOL	.0000	.0975	.0000	.0975	.0000	.0975	.0000	.0000	.0975	.0000
7 HIGH SCHOOL	.0000	.0000	.0975	.0000	.0975	.0000	.0975	.0000	.0000	.0975
8 VILL OFFICE BLDG	.0000	.0659	.0659	.0000	.0659	.0659	.0000	.0659	.0659	.0000
9 RECREATION CENTR	.0000	.0659	.0000	.0659	.0000	.0659	.0000	.0000	.0659	.0000
10 SHOPPING CENTER	.0000	.0000	.0023	.0000	.0023	.0000	.0023	.0000	.0000	.0023
11 COLLEGE	.0000	.0000	.0000	.0049	.0000	.0000	.0000	.0000	.0000	.0000
12 SHOPPING MALL	.0000	.0000	.0000	.0000	.0659	.0000	.0000	.0000	.0000	.0659
13 MALL RESTAURANT	.0000	.0000	.0000	.0000	.0659	.0000	.0000	.0000	.0000	.0000
14 OFFICE BUILDING	.0000	.0659	.0000	.0659	.0000	.0659	.0000	.0659	.0000	.0659
15 LO RISE INN	.0000	.0876	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16 HI RISE INN	.0000	.0000	.0975	.0000	.0000	.0000	.0975	.0000	.0975	.0000
17 INN RESTAURANT	.0000	.0786	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18 HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0975	.0000	.0000	.0000	.0000
19 HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0876	.0000	.0000	.0000	.0876	.0000
TOTAL	2.6761	3.1375	4.8298	2.2342	2.4510	4.3551	2.1971	2.1977	4.3768	2.2315

BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1 SINGLE FAMILY	1.0520	2.1099	1.0520	1.0520	2.1099	1.0520	1.0520	2.4566	1.4096	1.4096	29.4909
2 TOWN HOUSE	.4787	.9574	.4787	.4787	.9574	.4787	.4787	1.1170	.6383	.6383	13.4039
3 GARDEN APARTMENT	.2940	.5881	.2940	.2940	.5881	.2940	.2940	.6861	.3920	.3920	8.2328
4 ELEMENTRY SCHOOL	.0659	.1318	.0000	.0659	.1318	.0000	.0659	.1318	.0659	.0659	1.3843
5 VILL HI RISE APT	.1752	.1752	.1752	.1752	.1752	.1752	.1752	.3504	.1752	.1752	3.6796
6 MIDDLE SCHOOL	.0000	.0975	.0000	.0000	.0975	.0000	.0000	.0975	.0000	.0000	.6822
7 HIGH SCHOOL	.0000	.0000	.0975	.0000	.0000	.0975	.0000	.0000	.0975	.0000	.6822
8 VILL OFFICE BLDG	.0000	.0659	.0659	.0000	.0659	.0659	.0659	.0659	.0659	.0659	.9229
9 RECREATION CENTR	.0000	.0659	.0000	.0000	.0659	.0000	.0000	.0659	.0000	.0000	.4614
10 SHOPPING CENTER	.0000	.0000	.0023	.0000	.0000	.0023	.0000	.0000	.0023	.0000	.0160
11 COLLEGE	.0049	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0099
12 SHOPPING MALL	.0000	.0000	.0000	.0000	.0659	.0000	.0000	.0000	.0000	.0000	.1978
13 MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0659
14 OFFICE BUILDING	.0000	.0659	.0000	.0659	.0000	.0659	.0000	.0000	.0000	.0000	.5274
15 LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0876
16 HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2924
17 INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0786
18 HOSPITAL	.0000	.0000	.0000	.0000	.0975	.0000	.0000	.0000	.0000	.0000	.1949
19 HI RISE APARTMNT	.0000	.0876	.0000	.0000	.0000	.0000	.0876	.0000	.0000	.0000	.3504
TOTAL	2.0708	4.3452	2.1656	2.1318	4.3551	2.2315	2.2194	4.9712	2.8417	2.7420	60.7612

ORIGINAL PAGE IS OF POOR QUALITY

TABLE E-23.- Continued

(d) Total annual heat consumed (million Btu x 10^{-5})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1.	SINGLE FAMILY	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0039	.0068	.0135	.0135	.0169	.0237	.0237	.0270	.0338	.0338
5	VILL HI RISE APT	.0561	.1122	.1683	.2244	.2805	.3366	.3927	.4488	.5049	.5610
6	MIDDLE SCHOOL	.0000	.0226	.0226	.0453	.0453	.0679	.0679	.0679	.0905	.0905
7	HIGH SCHOOL	.0000	.0000	.0226	.0226	.0453	.0453	.0679	.0679	.0679	.0905
8	VILL OFFICE BLDG	.0000	.0043	.0086	.0086	.0129	.0172	.0172	.0215	.0259	.0259
9	RECREATION CENTR.	.0000	.0031	.0031	.0061	.0061	.0092	.0092	.0092	.0122	.0122
10	SHOPPING CENTER	.0000	.0000	.0013	.0013	.0026	.0026	.0038	.0038	.0038	.0051
11	COLLEGE	.0000	.0000	.0000	.0013	.0013	.0013	.0013	.0013	.0013	.0013
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0086	.0086	.0086	.0086	.0086	.0172
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	OFFICE BUILDING	.0000	.0069	.0069	.0139	.0138	.0206	.0206	.0275	.0275	.0344
15	LO RISE INN	.0000	.0216	.0216	.0216	.0216	.0216	.0216	.0216	.0216	.0216
16	HI RISE INN	.0000	.0000	.0292	.0292	.0292	.0292	.0583	.0583	.0875	.0875
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0401	.0401	.0401	.0401	.0401
19	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0280	.0280	.0280	.0280	.0561	.0561
	TOTAL	.0595	.1774	.2977	.3877	.5120	.6519	.7611	.8318	.9818	1.0773

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0372	.0439	.0439	.0473	.0541	.0541	.0575	.0642	.0676	.0710	.7366
5	VILL HI RISE APT	.6171	.6732	.7293	.7854	.8415	.8976	.9537	1.0659	1.1220	1.1781	11.9493
6	MIDDLE SCHOOL	.0905	.1131	.1131	.1131	.1358	.1358	.1358	.1584	.1584	.1584	1.8330
7	HIGH SCHOOL	.0905	.0905	.1131	.1131	.1131	.1358	.1358	.1358	.1584	.1584	1.6746
8	VILL OFFICE BLDG	.0259	.0302	.0345	.0345	.0388	.0431	.0474	.0517	.0560	.0603	.5646
9	RECREATION CENTR	.0122	.0153	.0153	.0153	.0184	.0184	.0184	.0214	.0214	.0214	.2479
10	SHOPPING CENTER	.0051	.0051	.0064	.0064	.0064	.0077	.0077	.0077	.0090	.0090	.0947
11	COLLEGE	.0027	.0027	.0027	.0027	.0027	.0027	.0027	.0027	.0027	.0027	.0364
12	SHOPPING MALL	.0172	.0172	.0172	.0172	.0258	.0258	.0258	.0258	.0258	.0258	.2838
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	OFFICE BUILDING	.0344	.0413	.0413	.0482	.0482	.0550	.0550	.0550	.0550	.0550	.6605
15	LO RISE INN	.0216	.0216	.0216	.0216	.0216	.0216	.0216	.0216	.0216	.0216	.4104
16	HI RISE INN	.0875	.0875	.0875	.0875	.0875	.0875	.0875	.0875	.0875	.0875	1.2830
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0401	.0401	.0401	.0401	.0803	.0803	.0803	.0803	.0803	.0803	.8431
19	HI RISE APARTMNT	.0561	.0841	.0841	.0841	.0841	.0841	.1122	.1122	.1122	.1122	1.1500
	TOTAL	1.1392	1.2660	1.3503	1.4166	1.5582	1.6494	1.7413	1.8907	1.9779	2.0417	21.7683

TABLE E-23.- Continued

(e) Total annual maintenance costs ($\$ \times 10^{-5}$)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.0702	.1405	.2633	.3159	.3685	.4740	.5266	.5792	.6847	.7373
2	TOWN HOUSE	.0319	.0638	.1197	.1436	.1675	.2154	.2394	.2633	.3112	.3351
3	GARDEN APARTMENT	.0196	.0392	.0735	.0882	.1029	.1323	.1470	.1617	.1911	.2058
4	ELEMENTRY SCHOOL	.0033	.0066	.0132	.0132	.0165	.0231	.0231	.0264	.0330	.0330
5	VILL HI RISE APT	.0088	.0175	.0263	.0350	.0438	.0526	.0613	.0701	.0788	.0876
6	MIDDLE SCHOOL	.0000	.0049	.0049	.0097	.0097	.0146	.0146	.0146	.0195	.0195
7	HIGH SCHOOL	.0000	.0000	.0049	.0049	.0097	.0097	.0146	.0146	.0146	.0195
8	VILL OFFICE BLDG	.0000	.0033	.0066	.0066	.0099	.0132	.0132	.0165	.0198	.0198
9	RECREATION CENTR	.0000	.0033	.0033	.0066	.0066	.0099	.0099	.0099	.0132	.0132
10	SHOPPING CENTER	.0000	.0000	.0001	.0001	.0002	.0002	.0003	.0003	.0003	.0005
11	COLLEGE	.0000	.0000	.0000	.0002	.0002	.0002	.0002	.0002	.0002	.0002
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0033	.0033	.0033	.0033	.0033	.0066
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0033	.0033	.0033	.0033	.0033	.0033
14	OFFICE BUILDING	.0000	.0033	.0033	.0066	.0066	.0099	.0099	.0132	.0132	.0165
15	LO RISE INN	.0000	.0044	.0044	.0044	.0044	.0044	.0044	.0044	.0044	.0044
16	HI RISE INN	.0000	.0000	.0049	.0049	.0049	.0049	.0097	.0097	.0196	.0196
17	INN RESTAURANT	.0000	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039
18	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0049	.0049	.0049	.0049	.0049
19	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0044	.0044	.0044	.0044	.0088	.0088
	TOTAL	.1338	.2907	.5322	.6439	.7664	.9892	1.0940	1.2039	1.4228	1.5343

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.7890	.8954	.9480	1.0006	1.1061	1.1587	1.2113	1.3341	1.4043	1.4745	15.4827
2	TOWN HOUSE	.3590	.4069	.4308	.4598	.5026	.5266	.5505	.6064	.6383	.6702	7.0370
3	GARDEN APARTMENT	.2205	.2499	.2646	.2793	.3087	.3234	.3381	.3724	.3920	.4116	4.3222
4	ELEMENTRY SCHOOL	.0363	.0428	.0428	.0461	.0527	.0527	.0560	.0626	.0659	.0692	.7185
5	VILL HI RISE APT	.0964	.1051	.1139	.1227	.1314	.1402	.1489	.1665	.1752	.1840	1.5061
6	MIDDLE SCHOOL	.0195	.0244	.0244	.0244	.0292	.0292	.0292	.0341	.0341	.0341	.3947
7	HIGH SCHOOL	.0195	.0195	.0244	.0244	.0244	.0292	.0292	.0292	.0341	.0341	.3606
8	VILL OFFICE BLDG	.0198	.0231	.0264	.0264	.0297	.0330	.0363	.0396	.0428	.0461	.4318
9	RECREATION CENTR	.0132	.0165	.0165	.0165	.0198	.0198	.0198	.0231	.0231	.0231	.2670
10	SHOPPING CENTER	.0005	.0005	.0006	.0006	.0006	.0007	.0007	.0007	.0008	.0008	.0084
11	COLLEGE	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0067
12	SHOPPING MALL	.0066	.0066	.0066	.0066	.0099	.0099	.0099	.0099	.0099	.0099	.1088
13	MALL RESTAURANT	.0033	.0033	.0033	.0033	.0033	.0033	.0033	.0033	.0033	.0033	.0526
14	OFFICE BUILDING	.0165	.0198	.0198	.0231	.0231	.0264	.0264	.0264	.0264	.0264	.3164
15	LO RISE INN	.0044	.0044	.0044	.0044	.0044	.0044	.0044	.0044	.0044	.0044	.0832
16	HI RISE INN	.0146	.0146	.0146	.0146	.0146	.0146	.0146	.0146	.0146	.0146	.2144
17	INN RESTAURANT	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0797
18	HOSPITAL	.0049	.0049	.0049	.0049	.0097	.0097	.0097	.0097	.0097	.0097	.1023
19	HI RISE APARTMNT	.0088	.0131	.0131	.0131	.0131	.0131	.0175	.0175	.0175	.0175	.1796
	TOTAL	1.6379	1.8551	1.9634	2.0700	2.2878	2.3993	2.5103	2.7589	2.9010	3.0381	32.0279

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TABLE E-23.- Concluded

(f) Service delivered (1000 gal x 10^{-5})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.2987	.5975	1.1200	1.3437	1.5675	2.0162	2.2400	2.4637	2.9125	3.1362
2	TOWN HOUSE	.1358	.2715	.5091	.6109	.7127	.9164	1.0182	1.1200	1.3236	1.4254
3	GARDEN APARTMENT	.0648	.1296	.2430	.2916	.3402	.4374	.4860	.5346	.6318	.6804
4	ELEMENTRY SCHOOL	.0045	.0091	.0181	.0181	.0226	.0317	.0317	.0362	.0453	.0453
5	VILL HI RISE APT	.0749	.1499	.2248	.2997	.3747	.4496	.5245	.5995	.6744	.7493
6	MIDDLE SCHOOL	.0000	.0302	.0302	.0605	.0605	.0907	.0907	.0907	.1209	.1209
7	HIGH SCHOOL	.0000	.0000	.0302	.0302	.0605	.0605	.0907	.0907	.0907	.1209
8	VILL OFFICE BLDG	.0000	.0057	.0115	.0115	.0172	.0230	.0230	.0287	.0345	.0345
9	RECREATION CENTR	.0000	.0041	.0041	.0082	.0082	.0123	.0123	.0123	.0164	.0164
10	SHOPPING CENTER	.0000	.0000	.0017	.0017	.0034	.0034	.0052	.0057	.0057	.0069
11	COLLEGE	.0000	.0000	.0000	.0018	.0018	.0018	.0018	.0018	.0018	.0018
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0057	.0057	.0057	.0057	.0057	.0115
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	OFFICE BUILDING	.0000	.0057	.0057	.0115	.0115	.0172	.0172	.0230	.0230	.0287
15	LO RISE INN	.0000	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389
16	HI RISE INN	.0000	.0000	.0288	.0288	.0288	.0288	.0576	.0576	.0865	.0865
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0536	.0536	.0536	.0536	.0536
19	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0375	.0375	.0375	.0375	.0749	.0749
	TOTAL	.5788	1.2822	2.2662	2.7572	3.2917	4.2247	4.7346	5.1997	6.1396	6.6322

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	3.3600	3.8087	4.0325	4.2562	4.7050	4.9287	5.1524	5.6749	5.9737	6.2724	65.8605
2	TOWN HOUSE	1.5273	1.7309	1.8327	1.9345	2.1382	2.2400	2.3418	2.5794	2.7151	2.8509	29.9342
3	GARDEN APARTMENT	.7290	.8262	.8748	.9234	1.0206	1.0692	1.1178	1.2312	1.2960	1.3608	14.2884
4	ELEMENTRY SCHOOL	.0498	.0588	.0588	.0639	.0724	.0724	.0769	.0860	.0905	.0950	.9867
5	VILL HI RISE APT	.8243	.8997	.9741	1.0491	1.1240	1.1989	1.2739	1.4237	1.4987	1.5736	15.9609
6	MIDDLE SCHOOL	.1209	.1511	.1511	.1511	.1814	.1814	.1814	.2116	.2116	.2116	2.4485
7	HIGH SCHOOL	.1209	.1209	.1511	.1511	.1511	.1814	.1814	.1814	.2116	.2116	2.2369
8	VILL OFFICE BLDG	.0345	.0402	.0460	.0460	.0517	.0575	.0632	.0690	.0747	.0805	.7531
9	RECREATION CENTR	.0164	.0204	.0204	.0204	.0245	.0245	.0245	.0286	.0286	.0286	.3311
10	SHOPPING CENTER	.0069	.0069	.0086	.0086	.0086	.0103	.0103	.0103	.0121	.0121	.1275
11	COLLEGE	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0486
12	SHOPPING MALL	.0115	.0115	.0115	.0115	.0172	.0172	.0172	.0172	.0172	.0172	.1894
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	OFFICE BUILDING	.0287	.0345	.0345	.0402	.0402	.0460	.0460	.0460	.0460	.0460	.5518
15	LO RISE INN	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.7391
16	HI RISE INN	.0865	.0865	.0865	.0865	.0865	.0865	.0865	.0865	.0865	.0865	1.2681
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0536	.0536	.0536	.0536	.1072	.1072	.1072	.1072	.1072	.1072	1.1260
19	HI RISE APARTMNT	.0749	.1124	.1124	.1124	.1124	.1124	.1499	.1499	.1499	.1499	1.5361
	TOTAL	7.0876	8.0044	8.4912	8.9506	9.8836	10.3761	10.8730	11.9464	12.5619	13.1464	138.3870

TABLE E-24.- CONVENTIONAL HOT-WATER EQUIPMENT

(a) Component capital and maintenance costs

Building type	Sizing flow, gal/hr (1)	Recovery rate, gal/hr	Capital cost, 1973 $	Maintenance cost, 1973 $ (2)	Annual flow, gal	Comments
Single family	10	30	197	9.85	$42x10^3$	Standard electric
Townhouse	10	30	197	9.85	42	Standard electric
Garden apartment	5	8	121	6.05	20	Electric low-boy
Village shopping center	33	45	228	11.40	172	Standard electric
Elementary school	247	500	6 592	329.60	452	Components (size 1)
Recreation center	134	500	6 592	329.60	409	Components (size 1)
Shopping mall (each phase)	332	500	6 592	329.60	574	Components (size 1)
Mall restaurant (total for all phases)	345	500	6 592	329.60	306	Components (size 1)
Office building (village and town center)	235	500	6 592	329.60	575	Components (size 1)
High-rise apartment (village and town center)	961	1500	8 761	438.05	3 747	Components (size 3)
Middle/high school	1434	2000	9 746	487.30	3 023	Components (size 4)
Low-rise inn	946	1500	8 761	438.05	2 882	Components (size 3)
High-rise inn	1277	2000	9 746	487.30	3 890	Components (size 4)
Inn restaurant	694	1000	7 860	393	2 555	Components (size 2)
Hospital	2265	4000	19 492	974.60	10 724	Components (two size 4)
College	124	120	495	24.75	180	Standard electric, commercial

[1]During an average day, this is the maximum hot-water requirement during a 1-hour period.

[2]Repair, maintenance, and replacement cost; ref. E-14 provides factors between 3 and 8 percent, depending on the equipment. In the interest of time, 5 percent was used for all equipment in this study.

TABLE E-24.- Concluded

(b) Costs of component sizes

Component	Cost, $			
	Size 1	Size 2	Size 3	Size 4
Boiler	5401	6624	7480	8318
Boost pump	200	210	227	260
Storage tank	895	895	895	934
Circulation pump	96	131	159	234
Total	6592	7860	8761	9746

TABLE E-25.- CONVENTIONAL WASTEWATER SYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FOR
CONVENTIONAL WASTE WATER SYSTEM - 11/29/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	5.779	0.033	0.005	5.817	5.812	5.812
1976	0.315	0.136	0.020	0.471	0.392	6.203
1977	4.968	0.315	0.047	5.330	3.995	10.198
1978	0.250	0.470	0.071	0.792	0.474	10.672
1979	0.258	0.598	0.092	0.947	0.490	11.162
1980	5.232	0.726	0.114	6.072	2.964	14.126
1981	0.274	0.873	0.139	1.286	0.499	14.625
1982	0.282	1.021	0.166	1.470	0.494	15.119
1983	5.921	1.218	0.202	7.342	2.339	17.459
1984	0.299	1.426	0.241	1.966	0.497	17.956
1985	0.308	1.579	0.270	2.157	0.474	18.430
1986	6.406	1.765	0.310	8.481	1.765	20.194
1987	0.327	2.050	0.368	2.745	0.454	20.648
1988	0.337	2.163	0.396	2.895	0.416	21.065
1989	7.327	2.398	0.448	10.173	1.385	22.450
1990	0.357	2.627	0.500	3.483	0.378	22.828
1991	0.368	2.876	0.557	3.800	0.358	23.186
1992	7.703	3.047	0.603	11.353	1.011	24.197
1993	0.520	3.497	0.704	4.722	0.337	24.534
1994	0.536	3.738	0.769	5.043	0.313	24.847

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	34.866	47.765	18.450
LESS RESID. VALUE	24.410	35.713	2.182
NET CAPITAL COSTS	10.456	12.052	16.268
COSTS FOR FUEL	2.721	6.021	0.946
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	20.243	32.558	5.451
TOTAL COSTS	33.420	50.631	22.665

CUMULATIVE SERVICE DELIVERED = 48.79100

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	0.715	0.979	0.378
LESS RESID. VALUE	0.500	0.732	0.045
NET CAPITAL COSTS	0.214	0.247	0.333
COSTS FOR FUEL	0.056	0.123	0.019
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.415	0.667	0.112
TOTAL COSTS	0.685	1.038	0.465

TABLE E-25.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL WASTE WATER SYSTEM - 11/29/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	5.779	0.033	0.006	5.818	5.813	5.813
1976	0.315	0.136	0.028	0.479	0.398	6.211
1977	4.968	0.315	0.074	5.357	4.012	10.223
1978	0.250	0.470	0.123	0.843	0.504	10.727
1979	0.258	0.598	0.174	1.029	0.531	11.258
1980	5.232	0.726	0.236	6.193	3.017	14.275
1981	0.274	0.873	0.316	1.463	0.565	14.840
1982	0.282	1.021	0.413	1.716	0.575	15.415
1983	5.921	1.218	0.550	7.690	2.438	17.853
1984	0.299	1.426	0.719	2.444	0.615	18.469
1985	0.308	1.579	0.882	2.769	0.605	19.074
1986	6.406	1.765	1.109	9.280	1.914	20.988
1987	0.327	2.050	1.439	3.816	0.628	21.616
1988	0.337	2.163	1.697	4.196	0.600	22.216
1989	7.327	2.398	2.101	11.827	1.589	23.805
1990	0.357	2.627	2.569	5.552	0.599	24.404
1991	0.368	2.876	3.136	6.380	0.598	25.002
1992	7.703	3.047	3.717	14.467	1.262	26.264
1993	0.520	3.497	4.757	8.775	0.622	26.886
1994	0.536	3.738	5.688	9.962	0.614	27.500

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	34.866	47.765	18.450
LESS RESID. VALUE	24.410	35.713	2.182
NET CAPITAL CØSTS	10.456	12.052	16.268
CØSTS FØR FUEL	2.721	29.734	3.599
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	20.243	32.558	5.451
TØTAL CØSTS	33.420	74.344	25.318

CUMULATIVE SERVICE DELIVERED = 48.79100

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.715	0.979	0.378
LESS RESID. VALUE	0.500	0.732	0.045
NET CAPITAL CØSTS	0.214	0.247	0.333
CØSTS FØR FUEL	0.056	0.609	0.074
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.415	0.667	0.112
TØTAL CØSTS	0.685	1.524	0.519

TABLE E-26.- CONVENTIONAL WASTEWATER SYSTEM (INPUTS TO DCF PROGRAM)

Year	Capital, 1973 $	Useful life, yr	Fuel, Btu (1)	O&M, 1973 $ (2)	Service delivered, gal
1975	2.974×10^6 2.473	30 75	3.993×10^9	0.0303×10^6	0.073×10^9
1976	.288	75	15.972	.121	.292
1977	2.974 1.440	30 75	35.833	.272	.656
1978	.216	75	51.965	.394	.950
1979	.216	75	63.999	.486	1.170
1980	2.974 1.280	30 75	75.486	.573	1.380
1981	.216	75	88.067	.669	1.610
1982	.216	75	100.101	.760	1.830
1983	2.974 1.432	30 75	115.964	.880	2.120
1984	.216	75	131.827	1.000	2.410
1985	.216	75	140.579	1.075	2.590
1986	2.974 1.388	30 75	153.707	1.167	2.81
1987	.216	75	173.399	1.316	3.17
1988	.216	75	177.775	1.348	3.25
1989	2.974 1.592	30 75	191.450	1.451	3.50
1990	.216	75	203.484	1.543	3.72
1991	.216	75	216.065	1.640	3.95
1992	2.974 1.419	30 75	222.629	1.687	4.07
1993	.288	75	247.791	1.880	4.53
1994	.288	75	257.637	1.951	4.71

[1]Fuel at 54.7 Btu/gal.

[2]Treatment plant O&M: Labor, 21.7¢/1000 gal; chemicals, 7.2¢/1000 gal; miscellaneous, 7.2¢/1000 gal. Collection system O&M, 5.4¢/1000 gal. Electrical power costs were included in the electrical power system costs.

TABLE E-27.- CONVENTIONAL WASTEWATER SYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1966 $	Total capital cost	
			1966 $	1973 $
1975	Village A first-yr development:			
	Three neighborhood submains			
	21 [illegible] ft of 8-in. sewer at $7/ft	147 840		
	3750 ft of 10-in. sewer at $8.25/ft	30 938		
	2100 ft of 15-in. sewer at $10/ft	21 000		
	Village center A submains			
	1500 ft of 8-in. sewer at $7/ft	10 500		
	1850 ft of 15-in. sewer at $10/ft	18 500		
	1100 ft of 18-in. sewer at $10.50/ft	11 550		
	550 ft of 24-in. sewer at $14/ft	7 700		
	Village center A main			
	97 subpain manholes	77 600		
	Lift stations			
	Six, 8-in. village A submains	90 000		
	Three, 15-in. village A submains	150 000		
	Village center A laterals			
	1900 ft of 8-in. sewer at $7/ft	13 300		
	Village center A lateral			
	15 manholes	6 000		
	Neighborhood development:			
	25 700 ft of 8-in. laterals (one-third)	179 900		
	96 manholes (one-third)	38 400		
	Mains:			
	3500 ft of 24-in. sewer at $14/ft	49 000		
	3350 ft of 27-in. sewer at $16.50/ft	55 275		
	1650 ft of 30-in. sewer at $19/ft	31 350		
	3500 ft of 42-in. sewer at $30/ft	105 000		
	6060 ft of 54-in. sewer at $42.60/ft	258 156		
	4800 ft of 60-in. sewer at $48.60/ft	233 280		
	4800 ft of 66-in. sewer at $56.10/ft	269 280		
	Manholes along mains:			
	38 manholes along highway to plant	30 400		
	47 manholes in town center	37 600	1.873×10^6	2.473×10^6
	2×10^6-gal/day treatment plant	2 253 000	2.253	2.974
1976	Village A:			
	One-third of neighborhood development	218 300	.2183	.2882
1977	Village A:			
	One-third of neighborhood development	218 300		
	Village B first-yr development	584 928		
	(same as village A 1975)			
	Neighborhood development:			
	19 275 8-in. laterals (one-fourth)	134 925		
	72 manholes (one-fourth)	28 800		
	Mains:			
	1800 ft of 30-in. sewer at $19/ft	34 200		
	2400 ft of 33-in. sewer at $20.25/ft	48 600		
	500 ft of 36-in. sewer at $21.50/ft	10 750		
	Manholes along mains:			
	11 manholes for interceptor to village B main	8 800		
	Town center laterals:			
	4650 ft of 8-in. sewer at $7/ft	32 550		
	2100 ft of 10-in. sewer at $8.25/ft	17 325		
	600 ft of 12-in. sewer at $9/ft	5 400		
	Village B subtractive delta from			
	first-yr development:			
	1300 ft of 15-in. sewer at $10/ft	-13 000		
	1100 ft of 18-in. sewer at $10.50/ft	-11 550		
	550 ft of 24-in. sewer at $14/ft	-7 700		
	Three village B mains	-2 400	1.090	1.440
	2×10^6-gal/day treatment plant	2 253 000	2.253	2.974
1978	Village B:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1979	Village B:			
	One-fourth of neighborhood development	163 725	.1637	.2161

TABLE E-27.- Continued

Year	Description	Major component capital cost, 1966 $	Total capital cost	
			1966 $	1973 $
1980	Village B:			
	One-fourth of neighborhood development	163 725		
	Village C first-yr development (same as village A 1975)	584 928		
	Neighborhood development (same as 1977)	163 725		
	Mains:			
	7200 ft of 24-in. sewer at $14/ft	100 800		
	Manholes along mains:			
	11 manholes from village C main to village B	8 800		
	Village C subtractive delta:			
	Three manholes	-2 400		
	Lift station:			
	Village C main to village B	-50 000	0.970x10⁶	1.280x10⁶
	2×10^6-gal/day treatment plant	2 253 000	2.253	2.974
1981	Village C:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1982	Village C:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1983	Village C:			
	One-fourth of neighborhood development	163 725		
	Village D first-yr development (same as village A 1975)	584 928		
	Neighborhood development (same as 1977)	163 725		
	Mains:			
	2250 ft of 42-in. sewer at $30/ft	67 500		
	Manholes along main:			
	Eight manholes from village D to interceptor	6 400		
	Five manholes from village D to interceptor	4 000		
	Village D subtractive delta:			
	650 ft of 15-in. sewer at $10/ft	-6 500		
	50 ft of 18-in. sewer at $10.50/ft	-525		
	50 ft of 24-in. sewer at $14/ft	-700		
	Three manholes	-2 400		
	Lift station:			
	One, 42-in. sewer	105 000		
	Laterals off mall:			
	300 ft of 8-in. sewer at $7/ft	2 100	1.087	1.435
	2×10^6-gal/day treatment plant	2 253 000	2.253	2.974
1984	Village D:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1985	Village D:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1986	Village D:			
	One-fourth of neighborhood development	163 725		
	Village E first-yr development (same as village A 1975)	584 928		
	Neighborhood development (same as 1977)	163 725		
	Mains:			
	6000 ft of 24-in. sewer at $14/ft	84 000		
	Manholes along mains:			
	Eight manholes from village E to town center	6 400		
	Village D subtractive delta:			
	Three manholes	-2 400		
	Lift station:			
	One, 24-in. sewer to town center main	50 000	1.051	1.388
	2×10^6-gal/day treatment plant	2 253 000	2.253	2.974
1987	Village E:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1988	Village E:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1989	Village E:			
	One-fourth of neighborhood development	163 725		
	Village F first-yr development (same as village A 1975)	584 928		
	Neighborhood development (same as 1977)	163 725		
	Mains:			
	4800 ft of 24-in. sewer at $14/ft	67 200		
	4800 ft of 36-in. sewer at $21.50/ft	103 200		

TABLE E-27.- Concluded

Year	Description	Major component capital cost, 1966 $	Total capital cost 1966 $	Total capital cost 1973 $
	Manholes along main:			
	15 manholes from village F main to village D	12 000		
	Village F subtractive delta:			
	Three manholes	-2 400		
	Lift station:			
	One, 36-in. village F sewer to village D	9[illegible] 000		
	Laterals off mall:			
	2800 ft of 10-in. sewer at $8.25/ft	23 100	$1.206x10^6$	$1.592x10^6$
	$2x10^6$-gal/day treatment plant	2 235 000	2.235	2.974
1990	Village F:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1991	Village F:			
	One-fourth of neighborhood development	163 725	.1637	.2161
1992	Village F:			
	One-fourth of neighborhood development	163 725		
	Village G first-yr development (same as village A 1975)	584 928		
	Neighborhood development (same as 1975)	218 300		
	Mains:			
	4800 ft of 24-in. sewer at $14/ft	67 200		
	Manholes along main:			
	Seven manholes along main to F interceptor	5 600		
	Village G subtractive delta:			
	Three manholes	-2 400	1.037	1.369
	$2x10^6$-gal/day treatment plant	2 235 000	2.235	2.974
1993	Village G:			
	One-third of neighborhood development	218 300	.2183	.2882
1994	Village G:			
	One-third of neighborhood development	218 300	.2183	.2882

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TABLE E-28.- CONVENTIONAL WASTEWATER SYSTEM (COMPONENT CAPITAL COSTS)

(a) Sewer mains

Component	Quantity, ft	Cost, 1966 $
Sewer, 8-in.:		
21 neighborhood mains, 7040 ft ea.	147 840	
Seven village center mains, 1500 ft ea.	10 500	
Seven village center laterals, 1900 ft ea.	13 300	
21 neighborhood laterals, 25 700 ft ea.	539 700	
Town center lateral, 4650 ft	4 650	
Office mall lateral, 300 ft	300	
Total	716 290	5 014 030 (7.00/ft)
Sewer, 10-in.:		
21 neighborhood mains, 1250 ft. ea.	26 250	
Town center lateral, 2100 ft	2 100	
Office mall laterals, 2800 ft	2 800	
Total	31 150	256 987 (8.25/ft)
Sewer, 12-in.:		
Town center laterals, 600 ft		5 400 (9.00/ft)
Sewer, 15-in.:		
21 neighborhood mains, 700 ft ea.	14 700	
Seven village center mains, 1850 ft ea.	12 950	
Subtractive, village B	-1 300	
Subtractive, village D	-650	
Total	25 700	257 000 (10.00/ft)
Sewer, 18-in.:		
Seven village center mains, 1100 ft ea.	7 700	
Subtractive, village B	-1 100	
Subtractive, village D	-50	
Total	6 550	68 775 (10.50/ft)
Sewer, 24-in.:		
Seven village center mains, 550 ft ea.	3 850	
Mains	3 500	
Subtractive, village B	-550	
Subtractive, village D	-50	
Mains	6 000	
Mains	4 800	
Mains	4 800	
Mains	7 200	
Total	29 550	413 700 (14.00/ft)
Sewer, 27-in.:		
Mains	3 350	55 275 (16.50/ft)
Sewer, 30-in.:		
Mains	1 650	
Village B mains	1 800	
	3 450	65 550 (19.00/ft)
Sewer, 33-in.:		
Village B mains	2 400	48 600 (20.25/ft)
Sewer, 36-in.:		
Village B mains	500	
Mains	4 800	
Total	5 300	113 950 (21.50/ft)
Sewer, 42-in.:		
Mains	5 750	
Total		172 500 (30.00/ft)
Sewer, 54-in.:		
Mains	6 060	258 156 (42.60/ft)
Sewer, 60-in.:		
Mains	4 800	233 280 (48.60/ft)
Sewer, 66-in.:		
Mains	4 800	269 280 (56.10/ft)

TABLE E-28.- Concluded

(b) Manholes and lift stations

Component	Quantity, ea.	Cost, 1966 $
Manholes for sewer mains:		
Village mains	679	
Freeway to plant	38	
Town center	47	
Village B main to interceptor	11	
Subtractive, village B	-3	
Village C main to village B	11	
Subtractive, village D	-3	
Village D main to interceptor	13	
Village E main to town center	8	
Subtractive, village E	-3	
Village F main to village D	15	
Main to village F interceptor	7	
Subtractive, village F	-3	
Subtractive, village C	-3	
Subtractive, village G	-3	
Total	811	648 800 (800/ea.)
Other manholes:		
Village centers	105	
Neighborhoods	2 016	
	2 121	848 400 (400/ea.)
Lift stations:		
Village sewer mains, 8-in., at $15 000 ea.	42	630 000
Village sewer mains, 15-in., at $50 000 ea.	21	1 050 000
Main, 24-in., at $50 000 ea.	2	100 000
Main, 42-in.	1	105 000
Main, 36-in.	1	90 000

(c) Cost summary

Total collection system capital, 1966 $ 10 704 683

Total collection system capital, 1973 $ 14 130 181

Treatment plant capital, 1973 $ 20 818 000

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TABLE E-29.- COST SUMMARY OF CONVENTIONAL WASTEWATER SYSTEM EQUIPMENT

(a) Sewer pipe

Diameter, in.	Quantity, ft	Unit price, 1966 $	Total cost, 1966 $
8	716 290	7.00	5 014 030
10	31 150	8.25	256 987
12	600	9.00	5 400
15	25 700	10.00	257 000
18	6 550	10.50	68 775
24	29 550	14.00	413 700
27	3 350	16.50	55 275
30	3 450	19.00	65 550
33	2 400	20.25	48 600
36	5 300	21.50	113 950
42	5 750	30.00	172 500
54	6 060	42.60	258 156
60	4 800	48.60	233 280
66	4 800	56.10	269 280

(b) Manholes and lift stations

Item description	Quantity, ea.	Unit price, 1966 $	Total cost, 1966 $
Manholes along mains	811	800	648 800
Other manholes	2121	400	848 400
Lift stations for 8-in. mains	42	15 000	630 000
Lift stations for 15-in. mains	21	50 000	1 050 000
Lift stations for 24-in. mains	2	50 000	100 000
Lift stations for 42-in. mains	1	105 000	105 000
Lift stations for 36-in. mains	1	90 000	90 000

(c) Cost summary

Total collection system capital, 1966 $	10 700 000+
Total collection system capital, 1973 $	14 124 000+
Seven treatment plants at $2 974 000 ea., 1973 $	20 818 000
Total capital cost, 1973 $	34 942 000

TABLE E-30.- CONVENTIONAL HVAC SYSTEM COSTS (DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 12/ 4/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL HVAC - 12/4/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	1.773	0.178	0.006	1.957	1.933	1.933
1976	2.244	0.426	0.021	2.692	2.290	4.223
1977	3.540	0.808	0.038	4.387	3.234	7.457
1978	1.802	1.024	0.052	2.878	1.800	9.257
1979	3.627	1.334	0.080	5.041	2.777	12.033
1980	3.426	1.739	0.098	5.263	2.498	14.531
1981	1.913	1.985	0.120	4.017	1.618	16.149
1982	1.960	2.251	0.138	4.349	1.518	17.667
1983	3.840	2.728	0.174	6.742	2.080	19.747
1984	4.003	3.104	0.205	7.313	1.956	21.703
1985	1.941	3.401	0.228	5.570	1.260	22.963
1986	4.230	3.951	0.268	8.450	1.698	24.661
1987	2.320	4.303	0.299	6.922	1.181	25.842
1988	2.180	4.657	0.328	7.165	1.059	26.901
1989	6.486	5.345	0.374	12.205	1.619	28.520
1990	2.704	5.783	0.415	8.903	0.995	29.515
1991	2.596	6.227	0.465	9.288	0.899	30.414
1992	5.578	6.985	0.525	13.089	1.125	31.540
1993	3.483	7.551	0.576	11.609	0.852	32.392
1994	3.300	8.115	0.623	12.038	0.766	33.158

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	44.271	62.947	20.056
LESS RESID. VALUE	44.270	64.834	3.961
NET CAPITAL CØSTS	0.000	-1.888	16.094
CØSTS FØR FUEL	2.281	5.035	0.797
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	44.833	71.895	12.305
TØTAL CØSTS	47.114	75.042	29.196

CUMULATIVE SERVICE DELIVERED = 1.44637

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	30.608	43.520	13.866
LESS RESID. VALUE	30.608	44.826	2.739
NET CAPITAL CØSTS	0.000	-1.305	11.127
CØSTS FØR FUEL	1.577	3.481	0.551
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	30.997	49.707	8.507
TØTAL CØSTS	32.574	51.883	20.186

TABLE E-30.- Concluded

(b) Escalation ratio of 15 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.150
THIS RUN MADE 12/ 4/73

D. C. F. ANALYSIS FOR
CONVENTIONAL HVAC - 12/4/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	1.773	0.178	0.008	1.959	1.935	1.935
1976	2.244	0.426	0.030	2.701	2.297	4.232
1977	3.540	0.808	0.060	4.409	3.248	7.480
1978	1.802	1.024	0.090	2.916	1.822	9.301
1979	3.627	1.334	0.150	5.111	2.812	12.113
1980	3.426	1.739	0.204	5.368	2.543	14.656
1981	1.913	1.985	0.271	4.169	1.675	16.331
1982	1.960	2.251	0.343	4.554	1.585	17.916
1983	3.840	2.728	0.475	7.042	2.165	20.082
1984	4.003	3.104	0.611	7.719	2.056	22.138
1985	1.941	3.401	0.742	6.085	1.370	23.508
1986	4.230	3.951	0.959	9.141	1.827	25.336
1987	2.320	4.303	1.170	7.793	1.323	26.659
1988	2.180	4.657	1.406	8.243	1.211	27.870
1989	6.486	5.345	1.758	13.588	1.790	29.659
1990	2.704	5.783	2.137	10.624	1.179	30.838
1991	2.596	6.227	2.618	11.441	1.099	31.937
1992	5.578	6.985	3.238	15.802	1.344	33.282
1993	3.483	7.551	3.888	14.922	1.085	34.367
1994	3.300	8.115	4.612	16.027	1.010	35.377

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	44.271	62.947	20.056
LESS RESID. VALUE	44.270	64.834	3.961
NET CAPITAL COSTS	0.000	-1.888	16.094
COSTS FOR FUEL	2.281	24.772	3.016
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	44.833	71.895	12.305
TOTAL COSTS	47.114	94.780	31.415

CUMULATIVE SERVICE DELIVERED = 1.44637

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	30.608	43.520	13.866
LESS RESID. VALUE	30.608	44.826	2.739
NET CAPITAL COSTS	0.000	-1.305	11.127
COSTS FOR FUEL	1.577	17.127	2.085
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	30.997	49.707	8.507
TOTAL COSTS	32.574	65.530	21.720

TABLE E-31.- CONVENTIONAL HVAC SYSTEM INPUTS TO THE DCF PROGRAM

YEAR	CAPITAL $(1973\ \$ \times 10^{-6})$	FUEL $(BTU \times 10^{9})$	ELECTRICITY $(KWH \times 10^{-6})$	OTHER O-AND-M INCLUDING LABOR $(1973\ \$ \times 10^{-6})$	MAN YEARS (O-AND-M)	A/C CAPACITY (TONS)
1975	1.6712	5.31	.000	.1626	1.17	4849.
1976	2.0540	16.91	.000	.3789	6.33	11857.
1977	3.1455	29.39	.000	.6973	11.00	21372.
1978	1.5543	38.10	.000	.8576	14.67	26808.
1979	3.0378	55.40	.000	1.0845	20.33	34978.
1980	2.7856	65.30	.000	1.3726	25.50	43827.
1981	1.5100	75.67	.000	1.5212	28.17	48753.
1982	1.5020	83.07	.000	1.6750	31.33	53960.
1983	2.8570	100.00	.000	1.9705	37.00	63232.
1984	2.8922	112.03	.000	2.1773	41.17	70532.
1985	1.3615	118.31	.000	2.3159	43.33	74889.
1986	2.8807	132.94	.000	2.6123	49.00	84311.
1987	1.5337	140.95	.000	2.7618	51.67	89387.
1988	1.3995	147.34	.000	2.9019	53.83	93944.
1989	4.0417	160.17	.000	3.2336	59.50	104367.
1990	1.6362	169.26	.000	3.3968	63.17	110093.
1991	1.5246	180.38	.000	3.5512	66.33	115430.
1992	3.1812	193.97	.000	3.8676	70.67	125355.
1993	1.9983	202.53	.000	4.0591	73.83	131463.
1994	1.7737	208.91	.000	4.2354	76.00	136962.

TABLE E-32.- CONVENTIONAL HVAC SYSTEM

(a) Input data array

	BUILDING	ELECTRICAL RATE $/KWH	FUEL RATE $/MBTU	LABOR RATE $/MAN-YEAR
1	SINGLE FAMILY	.0000	1.0200	10100.0
2	TOWN HOUSE	.0000	1.0200	10100.0
3	GARDEN APARTMENT	.0000	1.0200	10100.0
4	ELEMENTRY SCHOOL	.0000	1.0200	10100.0
5	VILL HI RISE APT	.0000	1.0200	10100.0
6	MIDDLE SCHOOL	.0000	1.0200	10100.0
7	HIGH SCHOOL	.0000	1.0200	10100.0
8	VILL OFFICE BLDG	.0000	1.0200	10100.0
9	RECREATION CENTR	.0000	1.0200	10100.0
10	SHOPPING CENTER	.0000	1.0200	10100.0
11	COLLEGE	.0000	1.0200	10100.0
12	SHOPPING MALL	.0000	1.0200	10100.0
13	OFFICE BUILDING	.0000	1.0200	10100.0
14	HI RISE INN	.0000	1.0200	10100.0
15	LO RISE INN	.0000	1.0200	10100.0
16	HOSPITAL	.0000	1.0200	10100.0
17	HI-RISE-APARTMNT	.0000	1.0200	10100.0

Matrix A

	BUILDING	A/C CAPACITY TONS	A/C POWER KW	ANNUAL HEAT-MBTU	ELECTRICITY KWH X .0001	PERSONNEL MEN	CAPITAL $ X.001	MAINTAINENCE $ X.01
1	SINGLE FAMILY	3.00	5.37	.00	.0000	.00	1.590	1.5400
2	TOWN HOUSE	3.00	5.37	.00	.0000	.00	.667	.6914
3	GARDEN APARTMENT	2.00	3.24	.00	.0000	.00	.550	.3850
4	ELEMENTRY SCHOOL	90.00	109.80	544.00	.0000	.50	20.350	6.8260
5	VILL HI RISE APT	500.00	592.00	2393.90	.0000	.33	79.253	27.3500
6	MIDDLE SCHOOL	253.00	331.00	1426.50	.0000	.50	61.438	20.5900
7	HIGH SCHOOL	251.00	331.00	1426.50	.0000	.50	61.436	20.5700
8	VILL OFFICE BLDG	650.00	762.00	1073.50	.0000	1.00	102.506	36.2300
9	RECREATION CENTR	266.00	318.00	468.05	.0000	.50	49.122	15.6100
10	SHOPPING CENTER	358.00	495.00	750.00	.0000	.50	93.196	30.0700
11	COLLEGE	450.00	534.00	968.50	.0000	1.00	64.592	21.3000
12	SHOPPING MALL	2224.00	2291.00	4016.00	.0000	1.50	1358.564	421.9400
13	OFFICE BUILDING	650.00	762.00	1073.50	.0000	1.00	102.506	36.2300
14	HI RISE INN	500.00	592.00	3376.00	.0000	1.00	78.800	27.2300
15	LO RISE INN	340.00	404.00	2248.00	.0000	1.00	67.197	23.8500
16	HOSPITAL	914.00	527.00	.00	.0000	1.00	60.110	19.8200
17	HI RISE APARTMNT	780.00	906.00	4727.00	.0000	1.00	125.155	42.8100
			Peak run	Fuel oil	Annual consumption	Operating man-years		

TABLE E-32.- Concluded

(b) Input schedule array

1	713.00	713.00	1247.00	534.00	534.00	1071.00	534.00	534.00
	1071.00	534.00	534.00	1071.00	534.00	534.00	1071.00	534.00
	534.00	1247.00	713.00	713.00				
2	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
3	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
4	1.00	1.00	2.00	.00	1.00	2.00	.00	1.00
	2.00	.00	1.00	2.00	.00	1.00	2.00	.00
	1.00	2.00	1.00	1.00				
5	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	4.00	2.00	2.00				
6	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
7	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
8	.00	1.00	1.00	.00	1.00	1.00	.00	1.00
	1.00	.00	.00	1.00	1.00	.00	1.00	1.00
	1.00	1.00	1.00	1.00				
9	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
10	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
11	.00	.00	.00	1.00	.00	.00	.00	.00
	.00	.00	1.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
12	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	1.00	.00	.00	.00	.00	1.00	.00
	.00	.00	.00	.00				
13	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	.00	.00	.00				
14	.00	.00	1.00	.00	.00	.00	1.00	.00
	1.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
15	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
16	.00	.00	.00	.00	.00	.50	.00	.00
	.00	.00	.00	.00	.00	.00	.50	.00
	.00	.00	.00	.00				
17	.00	.00	.00	.00	1.00	.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	.00	.00
	1.00	.00	.00	.00				

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TABLE E-33.- CONVENTIONAL HVAC SYSTEM ANNUAL CAPITAL, O&M COSTS, AND REQUIREMENTS

(a) Total annual capital expenditures ($\$ \times 10^{-6}$)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	1.0980	1.0980	1.9204	.8224	.8224	1.6493	.8224	.8224	1.6493	.8224
2	TOWN HOUSE	.2161	.2161	.3782	.1621	.1621	.3242	.1621	.1621	.3242	.1621
3	GARDEN APARTMENT	.1782	.1782	.3118	.1336	.1336	.2673	.1336	.1336	.2673	.1336
4	ELEMENTARY SCHOOL	.0203	.0203	.0407	.0000	.0203	.0407	.0000	.0203	.0407	.0000
5	VILL HI RISE APT	.1585	.1585	.1585	.1585	.1585	.1585	.1585	.1585	.1585	.1585
6	MIDDLE SCHOOL	.0000	.0614	.0000	.0614	.0000	.0614	.0000	.0000	.0614	.0000
7	HIGH SCHOOL	.0000	.0000	.0614	.0000	.0614	.0000	.0614	.0000	.0000	.0614
8	VILL OFFICE BLDG	.0000	.1025	.1025	.0000	.1025	.1025	.0000	.1025	.1025	.0000
9	RECREATION CENTR	.0000	.0491	.0000	.0491	.0000	.0491	.0000	.0000	.0491	.0000
10	SHOPPING CENTER	.0000	.0000	.0931	.0000	.0931	.0000	.0931	.0000	.0000	.0931
11	COLLEGE	.0000	.0000	.0000	.0646	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	1.3586	.0000	.0000	.0000	.0000	1.3586
13	OFFICE BUILDING	.0000	.1025	.0000	.1025	.0000	.1025	.0000	.1025	.0000	.1025
14	HI RISE INN	.0000	.0000	.0788	.0000	.0000	.0000	.0788	.0000	.0788	.0000
15	LO RISE INN	.0000	.0672	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0301	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.1252	.0000	.0000	.0000	.1252	.0000
	TOTAL	1.6712	2.0540	3.1455	1.5543	3.0378	2.7956	1.5100	1.5020	2.8570	2.8972

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.8224	1.6493	.8224	.8224	1.6493	.8224	.8224	1.9204	1.0980	1.0980	23.0538
2	TOWN HOUSE	.1621	.3242	.1621	.1621	.3242	.1621	.1621	.3782	.2161	.2161	4.5383
3	GARDEN APARTMENT	.1336	.2673	.1336	.1336	.2673	.1336	.1336	.3118	.1782	.1782	3.7422
4	ELEMENTARY SCHOOL	.0203	.0407	.0000	.0203	.0407	.0000	.0203	.0407	.0203	.0203	.4273
5	VILL HI RISE APT	.1585	.1585	.1585	.1585	.1585	.1585	.1585	.3170	.1585	.1585	3.3286
6	MIDDLE SCHOOL	.0000	.0614	.0000	.0000	.0614	.0000	.0000	.0614	.0000	.0000	.4301
7	HIGH SCHOOL	.0000	.0000	.0614	.0000	.0000	.0614	.0000	.0000	.0614	.0000	.4301
8	VILL OFFICE BLDG	.0000	.1025	.1025	.0000	.1025	.1025	.1025	.1025	.1025	.1025	1.4351
9	RECREATION CENTR	.0000	.0491	.0000	.0000	.0491	.0000	.0000	.0491	.0000	.0000	.3439
10	SHOPPING CENTER	.0000	.0000	.0931	.0000	.0000	.0931	.0000	.0000	.0931	.0000	.6520
11	COLLEGE	.0646	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.1292
12	SHOPPING MALL	.0000	.0000	.0000	.0000	1.3586	.0000	.0000	.0000	.0000	.0000	4.0757
13	OFFICE BUILDING	.0000	.1025	.0000	.1025	.0000	.1025	.0000	.0000	.0000	.0000	.8200
14	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2364
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0672
16	HOSPITAL	.0000	.0000	.0000	.0000	.0301	.0000	.0000	.0000	.0000	.0000	.0601
17	HI RISE APARTMNT	.0000	.1252	.0000	.0000	.0000	.0000	.1252	.0000	.0000	.0000	.5006
	TOTAL	1.3615	2.8807	1.5337	1.3995	4.0417	1.6362	1.5296	3.1812	1.9283	1.7737	44.2706

TABLE E-33.- Continued

(b) Total annual maintenance costs ($\$ \times 10^{-6}$)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.1098	.2196	.4116	.4939	.5761	.7410	.8233	.9055	1.0705	1.1527
2	TOWN HOUSE	.0229	.0998	.0880	.1008	.1176	.1512	.1680	.1848	.2184	.2352
3	GARDEN APARTMENT	.0175	.0299	.0468	.0561	.0655	.0842	.0936	.1029	.1216	.1310
4	ELEMENTRY SCHOOL	.0007	.0014	.0027	.0027	.0034	.0048	.0048	.0055	.0068	.0068
5	VILL HI RISE APT	.0055	.0109	.0164	.0219	.0273	.0328	.0383	.0438	.0492	.0547
6	MIDDLE SCHOOL	.0000	.0021	.0021	.0041	.0041	.0062	.0062	.0062	.0082	.0082
7	HIGH SCHOOL	.0000	.0000	.0021	.0021	.0041	.0041	.0062	.0062	.0062	.0082
8	VILL OFFICE BLDG	.0000	.0036	.0072	.0072	.0109	.0145	.0145	.0181	.0217	.0217
9	RECREATION CENTR	.0000	.0016	.0016	.0031	.0031	.0047	.0047	.0047	.0062	.0062
10	SHOPPING CENTER	.0000	.0000	.0030	.0030	.0060	.0060	.0090	.0090	.0090	.0120
11	COLLEGE	.0000	.0000	.0000	.0021	.0021	.0021	.0021	.0021	.0021	.0021
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0421	.0421	.0421	.0421	.0421	.0843
13	OFFICE BUILDING	.0000	.0036	.0036	.0072	.0072	.0109	.0109	.0145	.0145	.0181
14	HI RISE INN	.0000	.0000	.0027	.0027	.0027	.0027	.0054	.0054	.0082	.0082
15	LO RISE INN	.0000	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0024
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0010	.0010	.0010	.0010	.0010
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0043	.0043	.0043	.0043	.0086	.0086
	TOTAL	.1509	.3199	.5862	.7095	.8791	1.1151	1.2367	1.3585	1.5968	1.7615

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	1.2399	1.3999	1.4821	1.5643	1.7293	1.8115	1.8937	2.0858	2.1956	2.3054	24.2065
2	TOWN HOUSE	.2520	.2856	.3024	.3192	.3528	.3696	.3864	.4256	.4480	.4704	4.9395
3	GARDEN APARTMENT	.1403	.1590	.1684	.1778	.1965	.2058	.2152	.2370	.2495	.2620	2.7505
4	ELEMENTRY SCHOOL	.0075	.0089	.0089	.0096	.0109	.0109	.0116	.0130	.0137	.0143	.1488
5	VILL HI-RISE APT	.0602	.0656	.0711	.0766	.0820	.0875	.0930	.1039	.1094	.1149	1.1651
6	MIDDLE SCHOOL	.0092	.0103	.0103	.0103	.0124	.0124	.0124	.0144	.0144	.0144	.1668
7	HIGH SCHOOL	.0082	.0082	.0103	.0103	.0103	.0123	.0123	.0123	.0144	.0144	.1522
8	VILL OFFICE BLDG	.0217	.0254	.0290	.0290	.0326	.0362	.0399	.0435	.0471	.0507	.4746
9	RECREATION CENTR	.0047	.0078	.0078	.0078	.0094	.0094	.0094	.0109	.0109	.0109	.1264
10	SHOPPING CENTER	.0120	.0120	.0150	.0150	.0150	.0180	.0180	.0180	.0210	.0210	.2225
11	COLLEGE	.0043	.0043	.0043	.0043	.0043	.0043	.0043	.0043	.0043	.0043	.0575
12	SHOPPING MALL	.0843	.0843	.0843	.0843	.1264	.1264	.1264	.1264	.1264	.1264	1.3408
13	OFFICE BUILDING	.0181	.0217	.0217	.0254	.0254	.0290	.0290	.0290	.0290	.0290	.3478
14	HI RISE INN	.0082	.0082	.0082	.0082	.0082	.0082	.0082	.0082	.0082	.0082	.1198
15	LO RISE INN	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0453
16	HOSPITAL	.0010	.0010	.0010	.0010	.0020	.0020	.0020	.0020	.0020	.0020	.0208
17	HI RISE APARTMNT	.0086	.0128	.0128	.0128	.0128	.0128	.0171	.0171	.0171	.0171	.1755
	TOTAL	1.8792	2.1174	2.2400	2.3581	2.6326	2.7588	2.8812	3.1538	3.3134	3.4478	36.5105

TABLE E-33.- Continued

(c) Total annual O&M costs ($\$ \times 10^{-6}$)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.1090	.2196	.4116	.4939	.5761	.7410	.8233	.9055	1.0705	1.1527
2	TOWN HOUSE	.0224	.0448	.0840	.1008	.1176	.1512	.1680	.1848	.2184	.2352
3	GARDEN APARTMENT	.0125	.0249	.0468	.0561	.0655	.0842	.0936	.1029	.1216	.1310
4	ELEMENTRY SCHOOL	.0057	.0115	.0229	.0229	.0287	.0401	.0401	.0459	.0573	.0573
5	VILL HI RISE APT	.0122	.0244	.0366	.0488	.0610	.0732	.0854	.0976	.1098	.1220
6	MIDDLE SCHOOL	.0000	.0071	.0071	.0142	.0142	.0213	.0213	.0213	.0284	.0284
7	HIGH SCHOOL	.0000	.0000	.0071	.0071	.0142	.0142	.0213	.0213	.0213	.0284
8	VILL OFFICE BLDG	.0000	.0137	.0274	.0274	.0412	.0549	.0549	.0686	.0823	.0823
9	RECREATION CENTR	.0000	.0066	.0066	.0132	.0132	.0198	.0198	.0198	.0264	.0264
10	SHOPPING CENTER	.0000	.0000	.0081	.0081	.0161	.0161	.0242	.0242	.0242	.0322
11	COLLEGE	.0000	.0000	.0000	.0122	.0122	.0122	.0122	.0122	.0122	.0172
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0573	.0573	.0573	.0573	.0573	.1146
13	OFFICE BUILDING	.0000	.0137	.0137	.0274	.0274	.0412	.0412	.0549	.0549	.0686
14	HI RISE INN	.0000	.0000	.0128	.0128	.0128	.0128	.0256	.0256	.0385	.0385
15	LO RISE INN	.0000	.0125	.0125	.0125	.0125	.0125	.0125	.0125	.0125	.0125
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0060	.0060	.0060	.0060	.0060
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0144	.0144	.0144	.0144	.0288	.0288
	TOTAL	.1626	.3789	.6971	.8576	1.0845	1.3726	1.5212	1.6750	1.9705	2.1773

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	1.2349	1.3999	1.4821	1.5643	1.7293	1.8115	1.8937	2.0858	2.1956	2.3054	24.2065
2	TOWN HOUSE	.2520	.2856	.3024	.3192	.3528	.3696	.3864	.4256	.4480	.4704	4.4395
3	GARDEN APARTMENT	.1403	.1590	.1684	.1778	.1965	.2058	.2152	.2370	.2495	.2620	2.7505
4	ELEMENTRY SCHOOL	.0631	.0745	.0745	.0803	.0917	.0917	.0975	.1089	.1147	.1204	1.2497
5	VILL HI RISE APT	.1342	.1464	.1586	.1708	.1830	.1953	.2075	.2319	.2441	.2563	2.5993
6	MIDDLE SCHOOL	.0284	.0355	.0355	.0355	.0427	.0427	.0427	.0498	.0498	.0498	.5758
7	HIGH SCHOOL	.0284	.0284	.0355	.0355	.0355	.0426	.0426	.0426	.0497	.0497	.5259
8	VILL OFFICE BLDG	.0823	.0961	.1098	.1098	.1235	.1372	.1510	.1647	.1784	.1921	1.7477
9	RECREATION CENTR	.0264	.0331	.0331	.0331	.0397	.0397	.0397	.0463	.0463	.0463	.5355
10	SHOPPING CENTER	.0322	.0322	.0403	.0403	.0403	.0483	.0483	.0483	.0564	.0564	.5962
11	COLLEGE	.0245	.0245	.0245	.0245	.0245	.0245	.0245	.0245	.0245	.0245	.3302
12	SHOPPING MALL	.1146	.1146	.1146	.1146	.1719	.1719	.1719	.1719	.1719	.1719	1.8907
13	OFFICE BUILDING	.0686	.0823	.0823	.0961	.0961	.1098	.1098	.1098	.1098	.1098	1.3174
14	HI RISE INN	.0385	.0385	.0385	.0385	.0385	.0385	.0385	.0385	.0385	.0385	.5642
15	LO RISE INN	.0125	.0125	.0125	.0125	.0125	.0125	.0125	.0125	.0125	.0125	.2372
16	HOSPITAL	.0060	.0060	.0060	.0060	.0121	.0121	.0121	.0121	.0121	.0121	.1264
17	HI RISE APARTMNT	.0288	.0431	.0431	.0431	.0431	.0431	.0575	.0575	.0575	.0575	.5896
	TOTAL	2.3159	2.4123	2.7610	2.9019	3.2336	3.3968	3.5512	3.8676	4.0591	4.2354	44.8329

TABLE E-33.- Continued

(d) Total annual heat consumed (million Btu x 10^{-5})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0054	.0109	.0218	.0218	.0272	.0381	.0381	.0435	.0544	.0544
5	VILL HI RISE APT	.0477	.0953	.1430	.1907	.2383	.2860	.3336	.3813	.4290	.4766
6	MIDDLE SCHOOL	.0000	.0143	.0143	.0285	.0285	.0428	.0428	.0428	.0571	.0571
7	HIGH SCHOOL	.0000	.0000	.0143	.0143	.0285	.0285	.0428	.0428	.0428	.0571
8	VILL OFFICE BLDG	.0000	.0107	.0215	.0215	.0322	.0429	.0429	.0537	.0644	.0644
9	RECREATION CENTR	.0000	.0047	.0047	.0094	.0094	.0141	.0141	.0141	.0188	.0188
10	SHOPPING CENTER	.0000	.0000	.0075	.0075	.0150	.0150	.0225	.0225	.0225	.0300
11	COLLEGE	.0000	.0000	.0000	.0097	.0097	.0097	.0097	.0097	.0097	.0097
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0402	.0402	.0402	.0402	.0402	.0803
13	OFFICE BUILDING	.0000	.0107	.0107	.0215	.0215	.0322	.0322	.0429	.0429	.0537
14	HI RISE INN	.0000	.0000	.0338	.0338	.03[illegible]	.0338	.0675	.0675	.1013	.1013
15	LO RISE INN	.0000	.0225	.0225	.0225	.0225	.0225	.0225	.0225	.0225	.0225
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0473	.0473	.0473	.0473	.0946	.0946
	TOTAL	.0531	.1691	.2930	.3810	.5540	.6530	.7562	.8307	1.0000	1.1203

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0598	.0707	.0707	.0762	.0870	.0970	.0925	.1039	.1088	.1142	1.1859
5	VILL HI RISE APT	.5243	.5720	.6198	.6673	.7150	.7626	.8103	.9056	.9533	1.0009	10.1524
6	MIDDLE SCHOOL	.0571	.0713	.0713	.0713	.0856	.0856	.0854	.0999	.0999	.0999	1.1555
7	HIGH SCHOOL	.0571	.0571	.0713	.0713	.0713	.0856	.0856	.0856	.0999	.0999	1.0556
8	VILL OFFICE BLDG	.0644	.0751	.0859	.0959	.0966	.1073	.1181	.1288	.1394	.1503	1.4063
9	RECREATION CENTR	.0188	.0234	.0234	.0234	.0281	.0281	.0281	.0328	.0328	.0328	.3798
10	SHOPPING CENTER	.0300	.0300	.0375	.0375	.0375	.0450	.0450	.0450	.0525	.0525	.5550
11	COLLEGE	.0194	.0194	.0194	.0194	.0194	.0194	.0194	.0194	.0194	.0194	.2615
12	SHOPPING MALL	.0803	.0803	.0803	.0803	.1205	.1205	.1205	.1205	.1205	.1205	1.3253
13	OFFICE BUILDING	.0537	.0644	.0644	.0751	.0751	.0859	.0859	.0859	.0859	.0859	1.0306
14	HI RISE INN	.1013	.1013	.1013	.1013	.1013	.1013	.1013	.1013	.1013	.1013	1.4854
15	LO RISE INN	.0225	.0225	.0225	.0225	.0225	.0225	.0225	.0225	.0225	.0225	.4271
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0946	.1418	.1418	.1418	.1418	.1418	.1891	.1891	.1891	.1891	1.9384
	TOTAL	1.1831	1.3294	1.4095	1.4834	1.6017	1.6926	1.8038	1.9397	2.0253	2.0891	22.3588

TABLE E-33.- Concluded

(e) On-line tons of air-conditioning (ton x 10^{-4})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.2139	.4278	.8019	.9621	1.1223	1.4436	1.6038	1.7640	2.0853	2.2455
2	TOWN HOUSE	.0972	.1944	.3645	.4374	.5103	.6561	.7290	.8019	.9477	1.0206
3	GARDEN APARTMENT	.0648	.1296	.2430	.2916	.3402	.4374	.4860	.5346	.6318	.6804
4	ELEMENTRY SCHOOL	.0090	.0180	.0360	.0360	.0450	.0630	.0630	.0720	.0900	.0900
5	VILL HI RISE APT	.1000	.2000	.3000	.4000	.5000	.6000	.7000	.8000	.9000	1.0000
6	MIDDLE SCHOOL	.0000	.0253	.0253	.0506	.0506	.0759	.0759	.0759	.1012	.1012
7	HIGH SCHOOL	.0000	.0000	.0251	.0251	.0502	.0502	.0753	.0753	.0753	.1004
8	VILL OFFICE BLDG	.0000	.0650	.1300	.1300	.1950	.2600	.2600	.3250	.3900	.3900
9	RECREATION CENTR	.0000	.0266	.0266	.0532	.0532	.0798	.0798	.0798	.1064	.1064
10	SHOPPING CENTER	.0000	.0000	.0358	.0358	.0716	.0716	.1074	.1074	.1074	.1432
11	COLLEGE	.0000	.0000	.0000	.0450	.0450	.0450	.0450	.0450	.0450	.0450
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.2224	.2224	.2224	.2224	.2224	.4448
13	OFFICE BUILDING	.0000	.0650	.0650	.1300	.1300	.1950	.1950	.2600	.2600	.3250
14	HI RISE INN	.0000	.0000	.0500	.0500	.0500	.0500	.1000	.1000	.1500	.1500
15	LO RISE INN	.0000	.0340	.0340	.0340	.0340	.0340	.0340	.0340	.0340	.0340
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0207	.0207	.0207	.0207	.0207
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0780	.0780	.0780	.0780	.1560	.1560
	TOTAL	.4849	1.1857	2.1372	2.6808	3.4978	4.3827	4.8753	5.3960	6.3232	7.0532

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	2.4057	2.7220	2.8872	3.0474	3.3687	3.5289	3.6891	4.0632	4.2771	4.4910	47.1555
2	TOWN HOUSE	1.0935	1.2393	1.3122	1.3851	1.5309	1.6038	1.6767	1.8468	1.9440	2.0412	21.4326
3	GARDEN APARTMENT	.7290	.8262	.8748	.9234	1.0206	1.0692	1.1178	1.2312	1.2960	1.3608	14.2884
4	ELEMENTRY SCHOOL	.0990	.1170	.1170	.1260	.1440	.1440	.1530	.1710	.1800	.1890	1.9620
5	VILL HI RISE APT	1.1000	1.2000	1.3000	1.4000	1.5000	1.6000	1.7000	1.9000	2.0000	2.1000	21.3000
6	MIDDLE SCHOOL	.1012	.1265	.1265	.1265	.1518	.1518	.1518	.1771	.1771	.1771	2.0493
7	HIGH SCHOOL	.1004	.1004	.1255	.1255	.1255	.1506	.1506	.1506	.1757	.1757	1.8574
8	VILL OFFICE BLDG	.3900	.4550	.5200	.5200	.5850	.6500	.7150	.7800	.8450	.9100	8.5150
9	RECREATION CENTR	.1064	.1330	.1330	.1330	.1596	.1596	.1596	.1862	.1862	.1862	2.1546
10	SHOPPING CENTER	.1432	.1432	.1790	.1790	.1790	.2148	.2148	.2149	.2506	.2506	2.6492
11	COLLEGE	.0900	.0900	.0900	.0900	.0900	.0900	.0900	.0900	.0900	.0900	1.2150
12	SHOPPING MALL	.4448	.4448	.4448	.4448	.6672	.6672	.6672	.6672	.6672	.6672	7.3392
13	OFFICE BUILDING	.3250	.3900	.3900	.4550	.4550	.5200	.5200	.5200	.5200	.5200	6.2400
14	HI RISE INN	.1500	.1500	.1500	.1500	.1500	.1500	.1500	.1500	.1500	.1500	2.2000
15	LO RISE INN	.0340	.0340	.0340	.0340	.0340	.0340	.0340	.0340	.0340	.0340	.6460
16	HOSPITAL	.0207	.0207	.0207	.0207	.0414	.0414	.0414	.0414	.0414	.0414	.4347
17	HI RISE APARTMNT	.1560	.2340	.2340	.2340	.2340	.2340	.3120	.3120	.3120	.3120	3.1980
	TOTAL	7.4889	8.4311	8.9387	9.3944	10.4367	11.0093	11.5430	12.5355	13.1463	13.6962	144.6369

TABLE E-34.- CONVENTIONAL HVAC SYSTEM (UNIT CAPITAL AND O&M COSTS)

Item description	Quantity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization
		Cost/ unit	Total cost	Cost/ unit	Total cost	Operating load	Annual consumption	
Three-ton heat pump[1]	1		1 540		154	5.37 kW	16 760 kWh	Single-family dwellings; common to all options
Outdoor unit		1 100				5.0 kW		
Fan coil		410				.37 kW		
Controls		30						
Three-ton packaged air-conditioner[1]	1		667		69.14	5.37 kW	16 459 kWh	Townhouses; conventional only
Outdoor unit		407				5.0 kW		
Fan coil		230				.37 kW		
Controls		30						
Two-ton packaged air-conditioner[2]	1		550		38.50	3.24 kW	8 948 kWh	Garden apartments;
Outdoor unit		327				3.0 kW		conventional only
Fan coil		193				.24 kW		
Controls		30						
90-ton compression air-conditioner	1	13 200	13 200	462	462.00	81 kW		Elementary school; conventional only
13-hp boiler	1	1 300	1 300	32.50	32.50	431 300 Btu	154 998 kWh	
Cooling tower	1	1 840	1 840	55.20	55.20	18 kW	554x10⁶ Btu	
Fan coil unit (6 zones)	1	3 830	3 830	114.90	114.90	10.8 kW		
Controls	6	30	180	3.00	18.00			
Total			20 350		682.60			
250-ton compression air-conditioner	2	18 625	37 250	651.50	1 303	422 kW	834 570 kWh	Village high-rise apartments; conventional only
60-hp boiler	1	4 250	4 250	106	106		2383x10⁶ Btu	
Cooling tower	1	14 203	14 203	426	426	110 kW		
Fan coils (10 floors)	10	2 335	23 350	90	900	60 kW		
Total			79 053		2 735			
207-ton compression air-conditioner	2	20 138	40 276					Hospital
Cooling tower	1	14 300	14 300		1 982		673 332 kWh	
Fan coils	10	553	5 534					
Total			60 110					
760-ton air-conditioner	2	25 000	50 000					High-rise apartments
112-hp boiler	1	6 500	6 500		4 281		1 296 936 kWh	
Cooling tower	1	22 200	22 200					
Fan coils	21	2 355	49 455					
Total			128 155					
126-ton compression air-conditioner	2	14 620	29 240					Middle school; high school
40-hp boiler	1	4 769	4 769		2 059		440 730 kWh	
Cooling tower	1	4 628						
Air handler with automatic roll	2	10 593	21 186					
Support hardware			1 615					
Total			61 438					

[1]With 10-kW strip heater.
[2]With 7-kW strip heater.

TABLE E-34.- Concluded

Item description	Quantity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization
		Cost/ unit	Total cost	Cost/ unit	Total cost	Operating load	Annual consumption	
325-ton compression air-conditioner	2	21 280	42 560	1489				Village office or town center office
25-hp boiler	1	2 250	2 250	56	3 623	1 074 420 kWh		
Cooling tower	1	18 000	18 000	540				
Fan coil	3	13 232	39 696	1538				
Total			102 506					
225-ton compression air-conditioner	2	20 430	40 860		1 430			College
25-hp boiler	1	2 250	2 250		56	731 790 kWh		
Cooling tower	1	7 706	7 706		231			
Fan coils	5	2 755	13 776		413			
Total			64 592		2 130			
1112-ton compression air-conditioner	2	64 235	128 470					Shopping mall
100-hp boiler	1	8 275	8 275		42 144		3 769 428 kWh	
Cooling tower	1	57 000	57 000					
Fan coils	20	4 000	80 000					
Miscellaneous hardware			364 819					
Total			638 564					
250-ton compression air-conditioner	2	18 500	37 000					High-rise inn
90-hp boiler	1	5 200	5 200		2 723		832 770 kWh	
Cooling tower	1	13 000	13 000					
Fan coils	5	4 720	23 600					
Total			78 800					
170-ton compression air-conditioner	2	14 648	29 297					Low-rise inn
90-hp boiler	1	5 200	5 200		2 385		563 640 kWh	
Cooling tower	1	13 000	13 000					
Fan coils	3	6 560	19 680					
Total			67 177					
132.5-ton compression air-conditioner	2	15 629	31 258	1094				
12-hp boiler	1	851	851	21.27			473 000 kWh	
Cooling tower	1	2 160	2 160	64.80				
Fan coil	1	10 593	10 593	381				
Energy wheel	1	4 260	4 260	--				
Total			49 122	1561.07				
118-ton compression air-conditioner	3	14 600	43 800	1533				Village shopping center
20-hp boiler	1	1 100	1 100	27.50			503 000 kWh	
Cooling tower	1	5 900	5 900	177				
Air handler	3	13 232	39 696	1190				
Energy wheel	1	2 650	2 650	79.50				
Total			93 146	3007				

TABLE E-35.- CONVENTIONAL SOLID-WASTE SYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL CØST IS 102..00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL SØLID WASTE SYSTEM - 12/3/73

COST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V. CØST
1975	0.444	0.143	0.019	0.607	0.586	0.586
1976	0.408	0.270	0.032	0.711	0.584	1.169
1977	0.526	0.467	0.068	1.061	0.750	1.919
1978	0.563	0.619	0.095	1.276	0.778	2.697
1979	0.247	0.735	0.119	1.102	0.566	3.263
1980	0.618	0.897	0.142	1.657	0.757	4.020
1981	0.380	1.082	0.181	1.643	0.639	4.659
1982	0.647	1.193	0.203	2.044	0.700	5.359
1983	1.143	1.416	0.250	2.810	0.847	6.206
1984	0.473	1.593	0.290	2.356	0.600	6.806
1985	0.556	1.787	0.334	2.677	0.593	7.399
1986	0.814	1.991	0.392	3.196	0.620	8.019
1987	0.627	2.161	0.430	3.218	0.538	8.558
1988	1.162	2.428	0.473	4.062	0.599	9.156
1989	0.865	2.664	0.544	4.073	0.516	9.673
1990	0.781	2.865	0.605	4.251	0.467	10.140
1991	0.761	3.128	0.656	4.545	0.433	10.572
1992	1.473	3.509	0.771	5.753	0.483	11.055
1993	0.985	3.804	0.847	5.636	0.406	11.462
1994	0.626	4.077	0.923	5.627	0.350	11.811

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	9.727	14.098	4.110
LESS RESID. VALUE	4.291	6.719	0.411
NET CAPITAL CØSTS	5.436	7.380	3.699
CØSTS FØR FUEL	3.354	7.375	1.191
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	23.083	36.830	6.511
TØTAL CØSTS	31.874	51.585	11.401

CUMULATIVE SERVICE DELIVERED = 1.53050

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.356	9.212	2.685
LESS RESID. VALUE	2.804	4.390	0.268
NET CAPITAL CØSTS	3.552	4.822	2.417
CØSTS FØR FUEL	2.192	4.819	0.778
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	15.082	24.064	4.254
TØTAL CØSTS	20.826	33.705	7.449

TABLE E-35.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FØR
CØNVENTIØNAL SØLID WASTE SYSTEM - 12/3/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	0.444	0.143	0.025	0.613	0.591	0.591
1976	0.408	0.270	0.047	0.725	0.594	1.185
1977	0.526	0.467	0.108	1.101	0.776	1.961
1978	0.563	0.619	0.164	1.345	0.817	2.778
1979	0.247	0.735	0.225	1.208	0.619	3.397
1980	0.618	0.897	0.295	1.810	0.823	4.220
1981	0.380	1.082	0.410	1.872	0.725	4.945
1982	0.647	1.193	0.505	2.345	0.798	5.743
1983	1.143	1.416	0.681	3.240	0.970	6.713
1984	0.473	1.593	0.864	2.930	0.742	7.455
1985	0.556	1.787	1.088	3.431	0.755	8.210
1986	0.814	1.991	1.399	4.204	0.808	9.019
1987	0.627	2.161	1.685	4.473	0.742	9.761
1988	1.162	2.428	2.026	5.616	0.818	10.579
1989	0.865	2.664	2.553	6.082	0.763	11.343
1990	0.781	2.865	3.110	6.757	0.735	12.077
1991	0.761	3.128	3.693	7.582	0.715	12.792
1992	1.473	3.509	4.756	9.738	0.805	13.597
1993	0.985	3.804	5.721	10.511	0.749	14.346
1994	0.626	4.077	6.833	11.536	0.711	15.057

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	9.727	14.098	4.110
LESS RESID. VALUE	4.291	6.719	0.411
NET CAPITAL CØSTS	5.436	7.380	3.699
CØSTS FØR FUEL	3.354	36.189	4.436
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	23.083	36.830	6.511
TØTAL CØSTS	31.874	80.399	14.646

CUMULATIVE SERVICE DELIVERED = 1.53050

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.356	9.212	2.685
LESS RESID. VALUE	2.804	4.390	0.268
NET CAPITAL CØSTS	3.552	4.822	2.417
CØSTS FØR FUEL	2.192	23.645	2.899
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	15.082	24.064	4.254
TØTAL CØSTS	20.826	52.531	9.570

TABLE E-36.- CONVENTIONAL SOLID-WASTE SYSTEM (INPUTS TO DCF PROGRAM)

Year	Capital, 1973 \$ (1)	Fuel, Btu	Maintenance labor and material, 1973 \$ (2)	Operator labor, 1973 \$ (3)	Total O&M, 1973 \$ (4)	Annual service, tons
1975	0.4189×10^6	16.4×10^9	0.0210×10^6	0.110×10^6	0.131×10^6	0.55×10^4
1976	.3735	26.1	.0397	.200	.240	1.09
1977	.4673	52.4	.0630	.340	.403	2.31
1978	.4853	69.5	.0873	.430	.518	2.96
1979	.2070	83.0	.0976	.500	.598	3.64
1980	.4001	94.5	.1175	.590	.708	4.72
1981	.2322	114.3	.1292	.700	.829	5.12
1982	.3630	122.3	.1473	.740	.888	5.54
1983	.7008	143.5	.1823	.840	1.023	6.61
1984	.2898	158.3	.1968	.920	1.117	7.24
1985	.1999	173.4	.2065	1.010	1.217	7.95
1986	.3828	193.9	.2260	1.090	1.316	9.04
1987	.2222	203.0	.2373	1.150	1.387	9.45
1988	.5039	212.3	.2620	1.250	1.513	9.83
1989	.3828	232.6	.2815	1.330	1.612	10.90
1990	.2327	246.4	.2930	1.390	1.683	11.60
1991	.2179	254.4	.3040	1.480	1.784	12.45
1992	.5789	284.9	.3330	1.610	1.943	13.45
1993	.2324	298.0	.3450	1.700	2.045	14.02
1994	.0715	309.5	.3480	1.780	2.128	14.58

[1]See detailed equipment list for component costs.
[2]Maintenance labor and material at 5 percent of capital value.
[3]Operator labor at \$10 000/man-yr.
[4]Not including fuel and electricity.

TABLE E-37.- CONVENTIONAL SOLID-WASTE SYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	1	Pushcart, 1-yd³, at $140 ea.	5	140	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	2	Gravity chute systems at $350/floor plus $350			
		Two 12-story systems	40	9 100	
	1	Packer truck, 40-yd³	5	35 000	
	12	Blue Boxes, 10-yd³, at $600 ea.	5	7 200	
	1	Compactor container, 40-yd³	5	7 500	
	2	Compactor containers, 10-yd³ at $6000 ea.	5	12 000	
	1	Front-end loader, 40-yd³	5	35 000	
	2	Trucks for compactor container, at $3500	5	7 000	
	1	Tractor crawler	8	8 000	
	1	Steel-wheeled compactor	8	8 000	
	2	Incinerators, at $140 000	30	280 000	0.4189×10^6
1976	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd³	5	35 000	
	10	Blue Boxes, 10-yd³, at $600 ea.	5	6 000	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	2	Incinerators at $140 000	30	280 000	.3735
1977	3	Pushcarts, 1-yd³, at $140 ea.	5	420	
	8	Satellite vehicles, 2-yd³, at $2500 ea.	5	20 000	
	8	Gravity chute systems at $350/floor plus $350			
		Seven 12-story systems	40	31 850	
		One 22-story system	40	8 050	
	2	Packer trucks, 40-yd³, at $35 000	5	70 000	
	13	Blue Boxes, 10-yd³, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd³, at $7500 ea.	5	7 500	
	7	Compactor container, 10-yd³, at $6000 ea.	5	42 000	
	2	Incinerators at $140 000	30	280 000	.4676
1978	1	Pushcart, 1-yd³, at $140 ea.	5	140	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd³	5	35 000	
	9	Blue Boxes, 10-yd³, at $600 ea.	5	5 400	
	8	Compactor containers, 10-yd³, at $6000 ea.	5	48 000	
	1	Truck for compactor container hauling	5	3 500	
	1	Scraper	8	12 000	
	1	Dragline	8	20 000	
	1	Water truck	8	4 500	
	2	Incinerators, at $140 000 ea.	30	280 000	.4367

[1] A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-37.- Continued

Year	Quantity	Description	Useful life, yr [1]	Major component capital cost, 1973 $	Total capital cost, 1973 $
1979	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	2	Gravity chute systems at $350/floor plus $350			
		Two 12-story systems	40	9 100	
	1	Packer truck, 40-yd³	5	35 000	
	1	Blue Box, 10-yd³	5	600	
	2	Compactor containers, 10-yd³, at $6000 ea.	5	12 000	
	1	Incinerator	30	140 000	0.2070x10⁶
1980	2	Pushcarts, 1-yd³ at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	5	Gravity chute systems at $350/floor plus $350			
		Five 12-story systems	40	22 750	
	1	Packer truck, 40-yd³	5	35 000	
	16	Blue Boxes, 10-yd³, at $600 ea.	5	9 600	
	2	Compactor containers, 40-yd³, at $7500 ea.	5	15 000	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	1	Truck for compactor container hauling	5	3 500	
	2	Incinerators, at $140 000 each	30	280 000	.4001
1981	1	Pushcart, 1-yd³	5	140	
	8	Satellite vehicles, 2-yd³, at $2500 ea.	5	20 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd³	5	35 000	
	9	Blue Boxes, 10-yd³, at $600 ea.	5	5 400	
	3	Compactor containers, 10-yd³, at $6000 ea.	5	18 000	
	1	Incinerator	30	140 000	.2322
1982	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	3	Gravity chute systems at $350/floor plus $350			
		Two 12-story systems	40	9 100	
		One 22-story system	40	8 050	
	1	Packer truck, 40-yd³	5	35 000	
	1	Blue Box, 10-yd³	5	600	
	5	Compactor containers, 10-yd³, at $6000 ea.	5	30 000	
	2	Incinerators, at $140 000	30	280 000	.3630
1983	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	5	Gravity chute systems at $350/floor plus $350			
		Five 12-story systems	40	22 750	
	1	Packer truck, 40-yd³	5	35 000	
	13	Blue Boxes, 10-yd³, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd³	5	7 500	

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-37.- Continued

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
	9	Compactor containers, 10-yd^3, at $6000 ea.	5	54 000	
	1	Truck for compactor container hauling	5	3 500	
	4	Incinerators, at $140 000 ea.	30	560 000	0.7008×10^6
1984	1	Pushcart, 1-yd^3	5	140	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	5	Gravity chute systems at $350/floor plus $350			
		One 22-story system	40	8 050	
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd^3	5	35 000	
	9	Blue Boxes, 10-yd^3, at $600 ea.	5	5 400	
	5	Compactor containers, 10-yd^3, at $6000 ea.	5	30 000	
	1	Front-end loader, 40-yd^3	5	35 000	
	1	Tractor crawler	8	8 000	
	1	Incinerator	30	140 000	.2898
1985	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	1	Gravity chute system at $350/floor plus $350			
		One 12-story system	40	4 550	
	1	Packer truck, 40-yd^3	5	35 000	
	1	Blue Box, 10-yd^3	5	600	
	1	Compactor container, 10-yd^3	5	6 000	
	1	Truck for compactor container hauling	5	3 500	
	1	Incinerator	30	140 000	.1999
1986	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd^3	5	35 000	
	13	Blue Boxes, 10-yd^3, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd^3	5	7 500	
	4	Compactor containers, 10-yd^3, at $6000 ea.	5	24 000	
	2	Incinerators, at $140 000 ea.	30	280 000	.3828
1987	1	Pushcart, 1-yd^3	5	140	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd^3	5	35 000	
	9	Blue Boxes, 10-yd^3, at $600 ea.	5	5 400	
	3	Compactor containers, 10-yd^3, at $6000 ea.	5	18 000	
	1	Incinerator	30	140 000	.2222
1988	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	

(1)A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-37.- Continued

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	1	Gravity chute systems at $350/floor plus $350			
		One 12-story system	40	4 550	
	1	Packer truck, 40-yd³	5	35 000	
	1	Blue Box, 10-yd³	5	600	
	5	Compactor containers, 10-yd³, at $6000 ea.	5	30 000	
	1	Truck for compactor container hauling	5	3 500	
	3	Incinerators, at $140 000 ea.	30	420 000	0.5039x10⁶
1989	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd³	5	35 000	
	13	Blue Boxes, 10-yd³, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd³	5	7 500	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	2	Incinerators, at $140 000	30	280 000	.3828
1990	1	Pushcart, 1-yd³	5	140	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd³	5	35 000	
	9	Blue Boxes, 10-yd³, at $600 ea.	5	5 400	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	1	Incinerator	30	140 000	.2327
1991	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	1	Gravity chute system at $350/floor plus $350			
		One 12-story system	40	4 550	
	1	Packer truck, 40-yd³	5	35 000	
	1	Blue Box, 10-yd³	5	600	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	1	Truck for compactor container hauling	5	35 000	
	1	Incinerator	30	140 000	.2494
1992	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	8	Satellite vehicles, 2-yd³, at $2500 ea.	5	20 000	
	7	Gravity chute system at $350/floor plus $350			
		One 22-story system	40	8 050	
		Six 12-story systems	40	27 300	
	2	Packer trucks, 40-yd³, at $35 000 ea.	5	70 000	
	13	Blue Boxes, 10-yd³, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd³	5	7 500	

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-37.- Concluded

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
	3	Compactor containers, 10-yd^3, at $6000 ea.	5	18 000	
	3	Incinerators, at $140 000 ea.	30	420 000	$0.5789x10^6$
1993	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	3	Gravity chute systems at $350/floor $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd^3	5	35 000	
	10	Blue Boxes, 10-yd^3, at $600 ea.	5	6 000	
	4	Compactor containers, 10-yd^3, at $6000 ea.	5	24 000	
	1	Truck for compactor container hauling	5	3 500	
	1	Incinerator	30	140 000	.2324
1994	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd^3	5	35 000	
	1	Blue Box, 10-yd^3	5	600	
	2	Compactor containers, 10-yd^3, at $600 ea.	5	12 000	.0715

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-38.- MIUS OPTION I NEIGHBORHOOD COST SUMMARY

Subsystem	Capital cost, 1973 $
Electrical power:	
Generators and equipment	1 735 450
Distribution	577 800
General plant	12 303
Fuel distribution system	16 503
Total	2 342 056
Water supply[1]:	
Potable water supply piping	141 654
Fire water supply piping	192 552
Water pond	2 837
Water supply pumps	4 340
Neighborhood development	772 560
Treatment plant	122 689
Total	1 236 632
Hot water:	
Single-family-dwelling hot-water tanks	142 553
Townhouse hot-water tanks	38 880
Garden apartment hot-water tanks	11 664
Elementary school	1 237
Total	194 334
Wastewater:	
Lift stations	105 600
MIUS lift station	26 400
Wastewater piping	306 410
Manholes	33 088
Neighborhood development	288 156
Treatment plant	1 180 000
Total	1 939 654

[1]Does not include source supply materials and equipment costs.

TABLE E-38.- Concluded

Subsystem	Capital cost, 1973 $
HVAC:	
Single-family-dwelling heat pumps	1 098 020
Townhouse fan coil units	90 720
Garden apartment fan coil units	72 252
Elementary school fan coil	6 250
Absorption chiller	68 000
Compression chiller	56 500
Cooling pond	33 600
Hot-water boiler	24 680
Chilled-water pumps	21 820
Hot-water pumps	13 266
Gate valves	10 655
Insulated pipe, 12-in.	141 460
Insulated pipe, 3-in.	12 706
Insulated pipe, 1-1/4-in.	8 370
Pipe, 10-in.	129 106
Pipe, 8-in.	80 566
Pipe, 6-in.	33 782
Pipe, 5-in.	37 224
Pipe, 4-in.	17 376
Pipe, 3-1/2-in.	1 880
Pipe, 2-in.	15 232
Pipe, 1-1/2-in.	10 040
Total	1 983 505
Solid waste:	
Incinerators	340 000
Blue Boxes	5 400
Satellite collection vehicles	10 000
Front-end loader truck	35 000
Total	390 400
Controls:	
MIUS controls	336 000
MIUS building:	
Neighborhood	69 661
Wastewater	312 828
Common utility	126 960
Total	439 788
	8 932 030

TABLE E-39.- MIUS OPTION I ELECTRICAL POWER SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FOR
MIUS ELECTRICAL POWER - OPTION I (12/3/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	3.874	0.337	0.406	4.617	4.520	4.520
1976	3.449	0.628	1.004	5.081	4.233	8.753
1977	6.263	1.179	1.905	9.347	6.764	15.517
1978	5.291	1.669	2.891	9.851	6.086	21.603
1979	1.490	1.916	3.459	6.865	3.524	25.127
1980	5.365	2.463	4.461	12.289	5.661	30.787
1981	3.750	2.814	5.220	11.784	4.642	35.429
1982	2.664	3.201	6.131	11.996	4.052	39.481
1983	7.812	4.077	7.850	19.739	5.944	45.426
1984	5.249	4.718	9.067	19.034	4.900	50.325
1985	1.943	5.096	9.982	17.021	3.721	54.046
1986	7.387	5.823	11.592	24.802	4.843	58.889
1987	4.477	6.327	12.882	23.686	3.959	62.848
1988	3.183	6.934	14.517	24.634	3.549	66.397
1989	6.818	7.750	16.459	31.027	3.939	70.336
1990	5.145	8.410	18.263	31.819	3.483	73.819
1991	2.125	8.882	19.795	30.801	2.892	76.710
1992	10.340	10.129	22.815	43.284	3.623	80.333
1993	4.981	10.823	25.035	40.840	2.922	83.255
1994	4.446	11.512	27.363	43.321	2.688	85.943

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	68.205	96.054	32.197
LESS RESID. VALUE	44.951	58.254	4.170
NET CAPITAL COSTS	23.254	27.800	28.027
COSTS FOR FUEL	100.609	221.098	35.652
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	65.405	104.687	18.094
TOTAL COSTS	189.269	353.584	81.773

CUMULATIVE SERVICE DELIVERED = 10.77200

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	6.332	8.917	2.989
LESS RESID. VALUE	4.173	6.336	0.387
NET CAPITAL COSTS	2.159	2.581	2.602
COSTS FOR FUEL	9.340	20.525	3.310
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	6.072	9.718	1.680
TOTAL COSTS	17.570	32.824	7.591

TABLE E-39.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FØR
MIUS ELECTRICAL PØWER - ØPTIØN I (12/3/73)

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	3.874	0.337	0.534	4.745	4.631	4.631
1976	3.449	0.628	1.445	5.522	4.566	9.197
1977	6.263	1.179	3.001	10.444	7.485	16.682
1978	5.291	1.669	4.990	11.950	7.286	23.968
1979	1.490	1.916	6.539	9.945	5.055	29.024
1980	5.365	2.463	9.236	17.064	7.725	36.749
1981	3.750	2.814	11.838	18.402	7.129	43.878
1982	2.664	3.201	15.227	21.092	7.026	50.904
1983	7.812	4.077	21.354	33.243	9.783	60.687
1984	5.249	4.718	27.013	36.980	9.336	70.022
1985	1.943	5.096	32.572	39.611	8.577	78.599
1986	7.387	5.823	41.427	54.637	10.419	89.018
1987	4.477	6.327	50.421	61.225	10.060	99.078
1988	3.183	6.934	62.232	72.349	10.292	109.370
1989	6.818	7.750	77.274	91.843	11.413	120.783
1990	5.145	8.410	93.915	107.470	11.567	132.350
1991	2.125	8.882	111.486	122.492	11.412	143.763
1992	10.340	10.129	140.729	161.198	13.151	156.914
1993	4.981	10.823	169.134	184.938	13.047	169.961
1994	4.446	11.512	202.467	218.425	13.387	183.348

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	68.205	96.054	32.197
LESS RESID. VALUE	44.951	68.254	4.170
NET CAPITAL CØSTS	23.254	27.800	28.027
CØSTS FØR FUEL	100.609	1082.835	133.056
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	65.405	104.687	18.094
TØTAL CØSTS	189.269	1215.321	179.177

CUMULATIVE SERVICE DELIVERED = 10.77200

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.332	8.917	2.989
LESS RESID. VALUE	4.173	6.336	0.387
NET CAPITAL CØSTS	2.159	2.581	2.602
CØSTS FØR FUEL	9.340	100.523	12.352
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	6.072	9.718	1.680
TØTAL CØSTS	17.570	112.822	16.634

TABLE E-40.- MIUS OPTION I ELECTRICAL POWER SUBSYSTEM

(INPUTS TO DCF PROGRAM)

Year	Capital, 1973 $	Fuel, Btu	Other O&M, 1973 $	Service delivered, kWh
1975	3.652×10^6	344×10^9	0.308×10^6	3.76×10^7
1976	3.156	810	.558	8.84
1977	5.565	1463	1.017	15.97
1978	4.564	2115	1.398	23.06
1979	1.248	2410	1.558	26.32
1980	4.362	2960	1.944	32.27
1981	2.960	3299	2.157	36.02
1982	2.042	3690	2.382	40.24
1983	5.813	4500	2.945	49.15
1984	3.792	4950	3.309	54.09
1985	1.363	5190	3.470	56.65
1986	5.030	5740	3.850	62.59
1987	2.960	6075	4.061	66.34
1988	2.043	6520	4.321	71.28
1989	4.249	7040	4.689	76.92
1990	3.113	7440	4.940	81.34
1991	1.248	7680	5.065	83.87
1992	5.897	8430	5.608	92.05
1993	2.758	8810	5.818	96.34
1994	2.390	9171	6.008	100.1

TABLE E-41.- MIUS OPTION I ELECTRICAL POWER SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Village A powerplant:		
	Two 1750-kW generators	682 500	
	Two 1000-kVA transformers	20 800	
	General plant	12 677	
	Neighborhood A-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood A-2 powerplant (same as neighborhood A-1)	710 403	
	Neighborhood A-3 powerplant (same as neighborhood A-1)	710 403	
	One-third of distribution, village A	64 680	
	One-third of distribution, neighborhoods A-1, A-2, A-3	602 000	
	Fuel distribution (including fuel)	138 376	3.652×10^{6}
1976	Neighborhood A-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood A-2 powerplant (same as neighborhood A-1)	697 100	
	Neighborhood A-3 powerplant:		
	Three 1750-kW generators	1 023 750	
	Two 350-kVA transformers	14 600	
	One-third of distribution, village A	64 680	
	One-third of distribution, neighborhoods A-1, A-2, A-3	602 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	18 912	3.156
1977	Village A powerplant:		
	Two 1750-kW generators	682 500	
	Two 1000-kVA transformers	20 800	
	Neighborhood A-1 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood A-2 powerplant (same as neighborhood A-1)	341 250	
	Village B powerplant:		
	One 1750-kW generator	341 250	
	One 100-kVA transformer	10 400	
	General plant	12 677	
	Neighborhood B-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood B-2 powerplant (same as neighborhood B-1)	710 403	
	Neighborhood B-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	General plant	13 303	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	
	General plant	15 160	
	One-third of distribution, village A	61 220	
	One-third of distribution, neighborhoods A-1, A-2, A-3	602 000	
	One-fourth of distribution, village B	48 650	
	One-fourth of distribution, neighborhoods B-1, B-2, B-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	20 850	5.565
1978	Village B powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood B-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood B-2 powerplant (same as neighborhood B-1)	697 100	
	Neighborhood B-3 powerplant (same as neighborhood B-1)	697 100	

TABLE E-41.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	Town center powerplant:		
	Two 4415-kW generators	1 545 250	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village B	47 200	
	One-fourth of distribution, neighborhoods B-1, B-2, B-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	17 562	4.564x10[6]
1979	Village B powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood B-1 powerplant:		
	One 1750-kW generator	341 250	
	One-fourth of distribution, village B	47 200	
	One-fourth of distribution, neighborhoods B-1, B-2, B-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	17 562	1.248
1980	Village B powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood B-2 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood B-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	Village C powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	General plant	12 677	
	Neighborhood C-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood C-2 powerplant (same as neighborhood C-1)	710 403	
	Neighborhood C-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	General plant	13 303	
	One-fourth of distribution, village B	47 200	
	One-fourth of distribution, neighborhoods B-1, B-2, B-3	452 000	
	One-fourth of distribution, village C	48 650	
	One-fourth of distribution, neighborhoods C-1, C-2, C-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution (including fuel)	135 250	4.362
1981	Village C powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood C-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood C-2 powerplant (same as neighborhood C-1)	697 100	
	Neighborhood C-3 powerplant (same as neighborhood C-2)	697 100	
	One-fourth of distribution, village center	47 200	
	One-fourth of distribution, neighborhoods C-1, C-2, C-3	452 000	
	Fuel distribution	17 562	2.960
1982	Village C powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood C-1 powerplant:		
	One 1750-kW generator	341 250	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	

TABLE E-41.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	One-fourth of distribution, village C	47 200	
	One-fourth of distribution, neighborhoods C-1, C-2, C-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	17 562	2.042×10^6
1983	Village C powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood C-2 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood C-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	Village D powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	General plant	12 677	
	Neighborhood D-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood D-2 powerplant (same as neighborhood D-1)	710 403	
	Neighborhood D-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	General plant	13 303	
	Town center powerplant:		
	Two 4415-kW generators	1 545 250	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village C	47 200	
	One-fourth of distribution, neighborhoods C-1, C-2, C-3	452 000	
	One-fourth of distribution, village D	48 650	
	One-fourth of distribution, neighborhoods D-1, D-2, D-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	20 850	5.813
1984	Village D powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood D-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood D-2 powerplant (same as neighborhood D-1)	697 100	
	Neighborhood D-3 powerplant (same as neighborhood D-2)	697 100	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village D	47 200	
	One-fourth of distribution, neighborhoods D-1, D-2, D-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	17 562	3.792
1985	Village D powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood D-1 powerplant:		
	One 1750-kW generator	341 250	
	One-fourth of distribution, village D	47 200	
	One-fourth of distribution, neighborhoods D-1, D-2, D-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution (including fuel)	131 962	1.363
1986	Village D powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood D-2 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood D-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	

TABLE E-41.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	Village E powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	General plant	12 677	
	Neighborhood E-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood E-2 powerplant (same as neighborhood E-1)	710 403	
	Neighborhood E-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	General plant	13 303	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	One 900-kVA transformer	10 400	
	One-fourth distribution, village D	47 200	
	One-fourth of distribution, neighborhoods D-1, D-2, D-3	452 000	
	One-fourth of distribution, village E	48 650	
	One-fourth of distribution, neighborhoods E-1, E-2, E-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	20 850	5.030×10^6
1987	Village E powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood E-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood E-2 powerplant (same as neighborhood E-1)	697 100	
	Neighborhood E-3 powerplant (same as neighborhood E-2)	697 100	
	One-fourth of distribution, village E	47 200	
	One-fourth of distribution, neighborhoods E-1, E-2, E-3	452 000	
	Fuel distribution	17 562	2.960
1988	Village E powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood E-1 powerplant:		
	One 1750-kW generator	341 250	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village E	47 200	
	One-fourth of distribution, neighborhoods E-1, E-2, E-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	18 912	2.043
1989	Village E powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood E-2 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood E-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	Village F powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	General plant	12 677	
	Neighborhood F-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood F-2 powerplant (same as neighborhood F-1)	710 403	

TABLE E-41.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	Neighborhood F-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	General plant	13 303	
	One-fourth of distribution, village E	47 200	
	One-fourth of distribution, neighborhoods E-1, E-2, E-3	452 000	
	One-fourth of distribution, village F	48 650	
	One-fourth of distribution, neighborhoods F-1, F-2, F-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	22 413	4.249x10^{6}
1990	Village F powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood F-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood F-2 powerplant (same as neighborhood F-1)	697 100	
	Neighborhood F-3 powerplant (same as neighborhood F-2)	697 100	
	One-fourth of distribution, village F	47 200	
	One-fourth of distribution, neighborhoods F-1, F-2, F-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution (including fuel)	131 962	3.113
1991	Village F powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood F-1 powerplant:		
	One 1750-kW generator	341 250	
	One-fourth of distribution, village F	47 200	
	One-fourth of distribution, neighborhoods F-1, F-2, F-3	452 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	17 562	1.248
1992	Village F powerplant:		
	One 1750-kW generator	341 250	
	One 1000-kVA transformer	10 400	
	Neighborhood F-2 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood F-3 powerplant:		
	One 1750-kW generator	341 250	
	One 350-kVA transformer	7 300	
	Village G powerplant:		
	Two 1750-kW generators	682 500	
	Two 1000-kVA transformers	20 800	
	General plant	13 677	
	Neighborhood G-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	General plant	13 303	
	Neighborhood G-2 powerplant (same as neighborhood G-1)	710 403	
	Neighborhood G-3 powerplant (same as neighborhood G-2)	710 403	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	One 900-kVA transformer	10 400	
	One-fourth of distribution, village F	47 200	
	One-fourth of distribution, neighborhoods F-1, F-2, F-3	452 000	
	One-third of distribution, village G	64 680	
	One-third of distribution, neighborhoods G-1, G-2, G-3	602 000	
	One-fifteenth of distribution, town center	38 200	
	Fuel distribution	20 850	5.897

TABLE E-41.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1993	Neighborhood G-1 powerplant:		
	Two 1750-kW generators	682 500	
	Two 350-kVA transformers	14 600	
	Neighborhood G-2 powerplant (same as neighborhood G-1)	697 100	
	Neighborhood G-3 powerplant (same as neighborhood G-2)	697 100	
	One-third of distribution, village G	64 680	
	One-third of distribution, neighborhoods G-1, G-2, G-3	602 000	
	Fuel distribution	0	2.756×10^6
1994	Village G powerplant:		
	Two 1750-kW generators	682 500	
	Two 1000-kVA transformers	20 800	
	Neighborhood G-1 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood G-2 powerplant:		
	One 1750-kW generator	341 250	
	Neighborhood G-3 powerplant:		
	One 1750-kW generator	341 250	
	One-third of distribution, village G	61 220	
	One-third of distribution, neighborhoods G-1, G-2, G-3	602 000	
	Fuel distribution	0	2.390

TABLE E-42.- MIUS OPTION I ELECTRICAL POWER DISTRIBUTION

(COMPONENT CAPITAL COSTS)

Component	Cost, 1973 $
Village center[1]	
One-third of village center:	
350-MCM wire, 4700 ft at $2.78/ft	13 100
Ground wire, 1/0, 1570 ft at $1.26/ft	1 980
Twenty-seven 80-kW transformers at $1450 ea.	39 200
Three 800-kW switchgears at $3460 ea.	10 400
	64 680
Subtract one switchgear for last year	-3 460
Total	61 220
One-fourth of village center:	
350-MCM wire, 3525 ft at $2.78/ft	9 800
Ground wire, 1/0, 1180 ft at $1.26/ft	1 490
Twenty 80-kW transformers at $1450 ea.	29 000
Two 800-kW switchgears at $3640 ea.	6 900
	47 190
Add one transformer the first year	1 450
Total	48 640
Each neighborhood[2]	
One-third of three neighborhoods:	
500-MCM wire, 102 150 ft at $3.58/ft	366 000
Ground wire, 1/0, 34 050 ft at $1.26/ft	42 900
107 transformers (80-kW) at $1450 ea.	155 100
Eleven 800-kW switchgears at $3460 ea.	38 000
Total	602 000
One-fourth of three neighborhoods, 3/4 ($602 000)	452 000
Town center (same for options I and II), 1/15 totals:	
600-MCM wire, 3700 ft at $3.85/ft	14 230
Ground wire, 1/0, 1233 ft at $1.26/ft	1 550
9/15 of one 4450-kVA transformer at $20 000	12 000
Three 800-kW switchgears at $3460 ea.	10 400
Total	38 180
General plant items	
Each neighborhood MIUS:	
One 7000-gal fuel tank	3 333
7000-gal initial fuel load	1 000
One 5-ton crane	3 970
Tools	5 000
Each village center MIUS:	
One 6000-gal fuel tank	2 857
6000 gal of fuel	850
One 5-ton crane	3 970
Tools	5 000
Town center MIUS:	
One 10 000-gal fuel tank	4 760
10 000 gal of fuel	1 430
One 5-ton crane	3 970
Tools	5 000

[1]The village center requirements are 4700 feet of right-of-way, 350-MCM wire, 1/0 ground wire, eighty-one 80-kW transformers (88 kVA), and eight 800-kW switchgears.

[2]The requirements for each neighborhood are 34 050 feet of right-of-way, 500-MCM wire, 1/0 ground wire, 107 transformers (80-kW), and eleven 800-kW switchgears.

TABLE E-43.- DIESEL FUEL POWERPLANT (O&M COSTS)

[From ref. E-17]

Plant no.	No. of engines	Installation date (1)	Size, MW	Run factor	Cost, mills/kWh					
					Attendant and supervision	Lubrication oil	Supplies and miscellaneous	Engine repair	All other repairs	Total maintenance (2)
82	6	1971	36.80	70.3	2.02	0.59	0.54	1.83	0.41	3.37
76	13	1968	51.74	90.7	1.07	.48	.21	(3)	(3)	2.52
790	5	1951	11.00	74.0	2.65	.56	.20	.83	.08	1.67
97	8	1970	19.77	73.0	(4)	(4)	(4)	(4)	(4)	(4)
687	5	1969	7.95	78.7	2.41	.21	--	2.30	--	2.51
1416	7	1969	15.72	67.2	2.21	.54	.27	1.96	.22	2.99
										[5]2.61
										[6]3.00

[1]Date of latest installation.
[2]Does not include "attendant and supervision" costs.
[3]Total of 1.83 mills/kWh for both "engine repair" and "all other repairs."
[4]No data reported.
[5]Average maintenance costs for five plants, mid-1969 to mid-1970.
[6]1973 maintenance cost for options I and II diesel powerplants, assuming 50 percent labor and 50 percent materials and assuming 15 percent increase in cost to mid-1973.

TABLE E-44.- MIUS OPTION I FUEL DISTRIBUTION SUBSYSTEM

(ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Central storage tank[1]	33 000	
	Two 15-hp pumps	1 563 ea.	
	Two 2-hp pumps (village A)	675 ea.	
	Three 1-hp pumps (village A)	646 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	0.0570×10^6
1976	Two 2-hp pumps (town center)	675 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0189
1977	Two 2-hp pumps (village B)	675 ea.	
	Three 1-hp pumps (village B)	646 ea.	
	2-1/2 in. main	4 122	
	1-in. secondary	13 440	.0208
1978	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1979	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1980	Central storage tank[1]	33 000	
	Two 2-hp pumps (village C)	675 ea.	
	Three 1-hp pumps (village C)	646 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0538
1981	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1982	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1983	Two 2-hp pumps (village D)	675 ea.	
	Three 1-hp pumps (village D)	646 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0208
1984	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176

[1]Central storage tank initial loads of fuel at $81 400 added in years 1975, 1980, 1985, and 1990 in the DCF analysis.

TABLE E-44.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1985	Central storage tank[1] 2-1/2-in. main 1-in. secondary	33 000 4 122 13 440	0.0506×10^6
1986	Two 2-hp pumps (village E) Three 1-hp pumps (village E) 2-1/2-in. main 1-in. secondary	675 ea. 646 ea. 4 122 13 440	.0208
1987	2-1/2-in. main 1-in. secondary	4 122 13 440	.0176
1988	Two 2-hp pumps (town center) 2-1/2-in. main 1-in. secondary	675 ea. 4 122 13 440	.0189
1989	One 15-hp pump Two 2-hp pumps (village F) Three 1-hp pumps (village F) 2-1/2-in. main 1-in. secondary	1 563 675 ea. 646 ea. 4 122 13 440	.0224
1990	Central storage tank[1] 2-1/2-in. main 1-in. secondary	33 000 4 122 13 440	.0506
1991	2-1/2-in. main 1-in. secondary	4 122 13 440	.0176
1992	Two 2-hp pumps (village G) Three 1-hp pumps (village G) 2-1/2-in. main 1-in. secondary	675 ea. 646 ea. 4 122 13 440	.0208
1993	(2)	0	
1994	(2)	0	

[1]Central storage tank initial loads of fuel at $81 400 added in years 1975, 1980, 1985, and 1990 in the DCF analysis.

[2]Fuel distribution system complete.

TABLE E-45.- MIUS OPTION I WATER SUPPLY SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FØR
MIUS WATER SUPPLY SYSTEM - ØPTIØN I (11/30/73)

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE COST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	20.489	0.016	0.000	20.505	20.503	20.503
1976	0.487	0.040	0.000	0.528	0.454	20.958
1977	1.916	0.095	0.000	2.010	1.511	22.468
1978	0.235	0.146	0.000	0.381	0.238	22.707
1979	0.264	0.183	0.000	0.447	0.242	22.948
1980	3.458	0.229	0.000	3.687	1.818	24.767
1981	0.244	0.271	0.000	0.516	0.208	24.974
1982	0.252	0.316	0.000	0.568	0.198	25.172
1983	2.317	0.375	0.000	2.692	0.864	26.036
1984	0.267	0.438	0.000	0.705	0.184	26.221
1985	0.275	0.490	0.000	0.766	0.173	26.394
1986	4.761	0.554	0.000	5.315	1.127	27.521
1987	0.960	0.619	0.000	1.579	0.280	27.801
1988	0.301	0.693	0.000	0.994	0.147	27.948
1989	2.476	0.747	0.000	3.223	0.442	28.389
1990	0.321	0.919	0.000	1.240	0.138	28.527
1991	0.337	0.989	0.000	1.326	0.128	28.655
1992	4.417	1.095	0.000	5.512	0.499	29.154
1993	0.349	1.202	0.000	1.550	0.113	29.267
1994	0.359	1.295	0.000	1.654	0.104	29.371

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	36.103	44.486	27.629
LESS RESID. VALUE	28.417	36.701	2.242
NET CAPITAL CØSTS	7.686	7.785	25.387
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	6.618	10.712	1.742
TØTAL CØSTS	14.304	18.497	27.128

CUMULATIVE SERVICE DELIVERED = 53.48000

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.675	0.832	0.517
LESS RESID. VALUE	0.531	0.686	0.042
NET CAPITAL CØSTS	0.144	0.146	0.475
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.124	0.200	0.033
TØTAL CØSTS	0.267	0.346	0.507

TABLE E-46.- MIUS OPTION I WATER SUPPLY SUBSYSTEM

(INPUTS TO DCR PROGRAM)

Year	Capital, 1973 $	Useful life, yr	O&M, 1973 $ (1)	Service delivered, gal
1975	1.000×10^6 3.663 14.650	30 50 100	0.01486×10^6	0.12×10^9
1976	.089 .357	50 100	.0359	.29
1977	.340 1.362	50 100	.0817	.66
1978	.041 .162	50 100	.1222	.99
1979	.044 .177	50 100	.1486	1.20
1980	1.000 .362 1.450	30 50 100	.1808	1.46
1981	.039 .154	50 100	.208	1.68
1982	.039 .154	50 100	.235	1.90
1983	.345 1.379	50 100	.271	2.19
1984	.039 .154	50 100	.307	2.48
1985	.039 .154	50 100	.334	2.70
1986	1.000 .449 1.793	30 50 100	.366	2.96

[1]Treatment plant O&M labor at 5.92¢/1000 gal; chemicals at 2.69¢/1000 gal; miscellaneous at 2.28¢/1000 gal; distribution O&M at 1.48¢/1000 gal.

TABLE E-46.- Concluded

Year	Capital, 1973 $	Useful life, yr	O&M, 1973 $ (1)	Service delivered, gal
1987	0.127×10^6 .508	50 100	0.397×10^6	3.21×10^9
1988	.039 .154	50 100	.432	3.49
1989	.309 1.234	50 100	.452	3.65
1990	.039 .155	50 100	.540	4.36
1991	.040 .158	50 100	.564	4.56
1992	.558 .392 1.569	30 50 100	.606	4.90
1993	.039 .154	50 100	.646	5.22
1994	.039 .154	50 100	.676	5.46

[1]Treatment plant O&M labor at 5.92¢/1000 gal; chemicals at 2.69¢/1000 gal; miscellaneous at 2.28¢/1000 gal; distribution O&M at 1.48¢/1000 gal.

TABLE E-47.- MIUS OPTION I WATER SUPPLY SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Village A first-yr development:		
	Village center piping		
	600 ft of 2-in. PVC[1] at $2.16/ft	1 296	
	800 ft of 3-in. PVC at $3.80/ft	3 040	
	2250 ft of 6-in. PVC at $11.34/ft	25 515	
	1100 ft of 8-in. cast iron at $12.86/ft	14 146	
	Village center fire piping		
	700 ft of 6-in. monoline at $7.80/ft	5 460	
	2900 ft of 8-in. monoline at $11.24/ft	32 596	
	1550 ft of 15-in. monoline at $22.94/ft	35 557	
	Village center fire pumps		
	Three fire pumps, 1500 gal/min	12 504	
	Village center water pond		
	5694 yd^3 at 50¢/yd^3	2 847	
	Three neighborhood mains		
	450 ft of 1.5-in. PVC at $1.80/ft	810	
	3000 ft of 2-in. PVC at $2.16/ft	6 480	
	9450 ft of 3-in. PVC at $3.80/ft	35 910	
	25 500 ft of 6-in. PVC at $11.34/ft	289 170	
	7200 ft of 8-in. cast iron at $12.86/ft	92 592	
	Three neighborhood fire pipings		
	17 400 ft of 8-in. monoline at $11.24/ft	195 576	
	24 000 ft of 10-in. monoline at $15.92/ft	382 080	
	Three neighborhood water ponds		
	17 082 yd^3 at 50¢/yd^3	8 541	
	Potable water supply pumps		
	12 pumps, 206 gal/min	13 020	
	Neighborhood development (A):		
	One-third of potable water supply piping		
	22 200 ft of 3-in. PVC	84 360	
	One-third of fire piping		
	22 200 ft of 6-in. monoline	173 160	
	Water source supply pumps:		
	Pumping station	28 000	
	One pump, 3140 gal/min	4 578	
	Source supply piping:		
	79 200 ft of 42-in. cast iron at $170.57/ft	13 509 144	
	9600 ft of 16-in. cast iron at $36.84/ft	353 664	
	7750 ft of 24-in. cast iron at $70.18/ft	543 895	
	9360 ft of 30-in. cast iron at $98.27/ft	919 807	
	2400 ft of 36-in. cast iron at $136.58/ft	327 792	18.313×10^6
	7100 ft of 42-in. cast iron at $170.57/ft	1 211 047	
	4×10^6-gal/day treatment plant	1 000 000	1.000
1976	Village A:		
	One-third of neighborhood development	257 520	
	Town center pumps:		
	Two pumps, 500 gal/min	4 160	

[1]PVC = polyvinyl chloride.

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TABLE E-47.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	Town center potable water supply piping:		
	200 ft of 3-in. PVC at $3.80/ft	760	
	100 ft of 4-in. PVC at $5.49/ft	549	
	1300 ft of 8-in. cast iron at $12.86/ft	16 718	
	800 ft of 10-in. cast iron at $16.91/ft	13 528	
	2750 ft of 12-in. cast iron at $22.31/ft	61 353	
	3100 ft of 14-in. cast iron at $29.64/ft	91 884	
	Town center fire piping:		
	2300 ft of 12-in. monoline at $22.94/ft	52 762	
	5350 ft of 16-in. monoline at $34.63/ft	183 271	
	Town center fire pumps:		
	Three pumps, 1875 gal/min	12 159	0.697×10^6
1977	Village A:		
	One-third of neighborhood development	257 520	
	Village B first-yr development (same as village A 1975)	1 157 140	
	Neighborhood development (B):		
	One-fourth of potable water supply piping		
	16 650 ft of 3-in. piping	63 270	
	One-fourth of fire piping		
	16 650 ft of 6-in. piping	129 870	
	Town center pump:		
	One pump, 500 gal/min	2 080	
	Town center potable pump:		
	300 ft of 6-in. PVC at $11.34/ft	3 402	
	Town center fire piping:		
	300 ft of 12-in. monoline at $22.94/ft	6 882	
	Source supply piping:		
	2400 ft of 16-in. cast iron at $36.84/ft	88 416	1.708
1978	Village B:		
	One-fourth of neighborhood development	193 140	
	Town center potable water supply piping:		
	800 ft of 8-in. cast iron at $12.86/ft	10 288	
	Town center fire piping:		
	700 ft of 12-in. monoline at $22.94/ft	16 058	.219
1979	Village B:		
	One-fourth of neighborhood development	193 140	
	Town center pump:		
	One pump, 500 gal/min	2 080	
	Town center potable water supply piping:		
	300 ft of 3-in. PVC at $3.80/ft	1 140	
	100 ft of 4-in. PVC at $5.49/ft	549	
	2100 ft of 6-in. PVC at $11.34/ft	23 814	
	Town center fire piping:		
	1900 ft of 8-in. monoline at $11.24/ft	21 356	
	100 ft of 12-in. monoline at $22.94/ft	2 294	.244

TABLE E-47.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1980	Village B:		
	One-fourth of neighborhood development	193 140	
	Village C first-yr development (same as village A 1975)	1 157 140	
	Neighborhood development (C) (same as 1977)	193 140	
	Town center potable water supply piping:		
	300 ft of 6-in. PVC at $11.34/ft	3 402	
	Town center fire piping:		
	350 ft of 3-in. monoline at $11.24/ft	3 934	
	4100 ft of 6-in. monoline at $34.63/ft	141 983	
	Source supply piping:		
	7200 ft of 6-in. cast iron at $36.84/ft	265 248	1.958×10^6
	4×10^6-gal/day treatment plant	1 000 000	1.000
1981	Village C:		
	One-fourth of neighborhood development	193 140	.193
1982	Village C:		
	One-fourth of neighborhood development	193 140	.193
1983	Village C:		
	One-fourth of neighborhood development	193 140	
	Village D first-yr development (same as village A 1975)	1 157 140	
	Neighborhood development (D) (same as 1977)	193 140	
	Town center potable water supply piping:		
	100 ft of 4-in. PVC at $5.49/ft	549	
	Town center fire piping:		
	100 ft of 12-in. monoline at $22.94/ft	2 294	
	Source supply pump:		
	One supply pump, 3140 gal/min	4 578	
	Source supply piping:		
	2500 ft of 24-in. cast iron at $70.18/ft	175 450	1.726
1984	Village D:		
	One-fourth of neighborhood development	193 140	.193
1985	Village D:		
	One-fourth of neighborhood development	193 140	.193
1986	Village D:		
	One-fourth of neighborhood development	193 140	
	Village E first-yr development (same as village A 1975)	1 157 140	
	Neighborhood development (E) (same as 1977)	193 140	
	Source supply piping:		
	14 200 ft of 16-in. cast iron at $36.84/ft	523 128	
	2400 ft of 24-in. cast iron at $70.18/ft	175 380	2.242
	4×10^6-gal/day treatment plant	1 000 000	1.000

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TABLE E-47.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1987	Village E:		
	One-fourth of neighborhood development	193 140	
	Source supply piping:		
	12 000 ft of 16-in. cast iron at $36.84/ft	442 080	0.635×10^6
1988	Village E:		
	One-fourth of neighborhood development	193 140	.193
1989	Village E:		
	One-fourth of neighborhood development	193 140	
	Village F first-yr development (same as village A 1975)	1 157 140	
	Neighborhood development (F) (same as 1977)	193 140	1.543
1990	Village F:		
	One-fourth of neighborhood development	193 140	
	Town center potable water supply piping:		
	100 ft of 4-in. PVC at $5.49/ft	549	
	Town center fire piping:		
	100 ft of 12-in. monoline at $22.94/ft	2 294	.196
1991	Village F:		
	One-fourth of neighborhood development	193 140	
	Source supply pump:		
	One supply pump, 3140 gal/min	4 578	.198
1992	Village F:		
	One-fourth of neighborhood development	193 140	
	Village G first-yr development (same as village A 1975)	1 157 140	
	Neighborhood development (G) (same as 1975)	257 520	
	Source supply piping:		
	9600 ft of 16-in. cast iron at $36.84/ft	353 664	
	2×10^6-gal/day treatment plant	558 000	2.519
1993	Village G:		
	One-third of neighborhood development	257 200	.257
1994	Village G:		
	One-third of neighborhood development	257 200	.257

TABLE E-48.- MIUS OPTION I WATER SUPPLY SUBSYSTEM (COMPONENT CAPITAL COSTS)

Component	Quantity, ft	Cost, $
Cast iron pipe, 8-in. (no trenching):		
Village center, (1100 ft x 7)	7 700	
Neighborhood mains, (2400 ft x 21)	50 400	
CBD	2 100	
Total	60 200	774 172 (12.86/ft)
Cast iron pipe, 10-in. (no trenching):		
CBD	800	13 528 (16.91/ft)
Cast iron pipe, 12-in. (no trenching):		
CBD	2 750	61 353 (22.31/ft)
Cast iron pipe, 14-in. (no trenching):		
CBD	3 100	91 884 (29.64/ft)
Cast iron pipe, 16-in. (includes trenching):		
Source supply	55 000	2 026 200 (36.84/ft)
Cast iron pipe, 24-in. (includes trenching):		
Source supply	21 650	877 777 (70.18/ft)
Cast iron pipe, 30-in. (includes trenching):		
Source supply	9 360	919 807 (98.27/ft)
Cast iron pipe, 36-in. (includes trenching):		
Source supply	2 400	327 792 (136.58/ft)
Cast iron pipe, 42-in. (includes trenching):		
15 miles from source	79 200	
Source supply	7 100	
Total	86 300	14 720 191 (170.57/ft)
PVC pipe, 1.5-in. (no trenching):		
Neighborhood mains (150 ft x 21)	3 150	5 670 (1.80/ft)
PVC pipe, 2-in. (no trenching):		
Village center (600 ft x 7)	4 200	
Neighborhood mains (1000 ft x 21)	21 000	
Total	25 200	54 432 (2.16/ft)
PVC pipe, 3-in. (no trenching):		
Village center (800 ft x 7)	5 600	
Neighborhood mains (3150 ft x 21)	66 150	
Neighborhood street mains (22 200 ft x 21)	466 200	
CBD	500	
Total	538 450	2 046 110 (3.80/ft)

TABLE E-48.- Concluded

Component	Quantity, ft	Cost, $
PVC pipe, 4-in. (no trenching):		
CBD	400	2 196 (5.49/ft)
PVC pipe, 6-in. (no trenching):		
Village center (2250 ft x 7)	15 750	
CBD	2 700	
Total	18 450	209 223 (11.34/ft)
Monoline pipe, 6-in. (no trenching):		
Village center (700 ft x 7)	4 900	
Neighborhood street mains (22 200 ft x 21)	466 200	
Total	471 100	3 674 580 (7.80/ft)
Monoline pipe, 8-in. (no trenching):		
Village center (2900 ft x 7)	20 300	
Neighborhood (8000 ft x 21)	168 000	
Town center	2 250	
Total	190 550	2 141 782 (11.24/ft)
Monoline pipe, 10-in. (no trenching):		
Neighborhood (8000 ft x 21)	168 000	2 674 560 (15.92/ft)
Monoline pipe, 12-in. (no trenching):		
Village center (1550 ft x 7)	10 850	
Town center	3 600	
Total	14 450	331 483 (22.94/ft)
Monoline pipe, 16-in. (no trenching):		
Town center	9 450	327 254 (34.63/ft)
Water supply pumps, 206-gal/min:		
84 at $1085 ea.		91 140
Pumping station		28 000
Water source pumps, 3140-gal/min:		
Three at $4578 ea.		13 734
CBD pumps, 500-gal/min:		
Four at $2080 ea.		8 320
Fire pumps for village complexes, 1500-gal/min:		
21 at $4168 ea.		87 528

TABLE E-49.- MIUS OPTIONS I AND II HOT-WATER SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 12/ 5/73

D. C. F. ANALYSIS FOR
MIUS HOT WATER (USED FOR BOTH OPTIONS) - 12/5/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	0.208	0.011	0.000	0.219	0.217	0.217
1976	0.225	0.023	0.000	0.248	0.213	0.430
1977	0.389	0.043	0.000	0.433	0.323	0.753
1978	0.176	0.054	0.000	0.229	0.146	0.899
1979	0.186	0.065	0.000	0.251	0.139	1.038
1980	0.370	0.086	0.000	0.456	0.221	1.259
1981	0.191	0.098	0.000	0.289	0.119	1.378
1982	0.197	0.111	0.000	0.308	0.110	1.488
1983	0.405	0.136	0.000	0.540	0.171	1.659
1984	0.212	0.150	0.000	0.362	0.097	1.757
1985	0.212	0.166	0.000	0.378	0.088	1.845
1986	0.442	0.194	0.000	0.635	0.131	1.976
1987	0.227	0.211	0.000	0.438	0.077	2.053
1988	0.233	0.229	0.000	0.462	0.070	2.123
1989	0.485	0.261	0.000	0.746	0.101	2.223
1990	0.251	0.282	0.000	0.532	0.061	2.284
1991	0.257	0.304	0.000	0.561	0.056	2.340
1992	0.611	0.344	0.000	0.955	0.085	2.425
1993	0.360	0.373	0.000	0.733	0.055	2.480
1994	0.367	0.403	0.000	0.770	0.050	2.531

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	4.211	6.003	1.919
LESS RESID. VALUE	4.211	6.183	0.378
NET CAPITAL COSTS	0.000	-0.180	1.541
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	2.212	3.544	0.612
TOTAL COSTS	2.212	3.364	2.153

CUMULATIVE SERVICE DELIVERED = 13.83871

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	0.304	0.434	0.139
LESS RESID. VALUE	0.304	0.447	0.027
NET CAPITAL COSTS	0.000	-0.013	0.111
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.160	0.256	0.044
TOTAL COSTS	0.160	0.243	0.156

TABLE E-51.- MIUS HOT-WATER SUBSYSTEM (UNIT CAPITAL AND O&M COSTS)

(a) Input data array

	BUILDING	ELECTRICAL RATE $/KWH	FUEL RATE $/MBTU	LABOR RATE $/MAN-YEAR
1	SINGLE FAMILY	.0000	.0000	10100.0
2	TOWN HOUSE	.0000	.0000	10100.0
3	GARDEN APARTMENT	.0000	.0000	10100.0
4	ELEMENTRY SCHOOL	.0000	.0000	10100.0
5	VILL HI RISE APT	.0000	.0000	10100.0
6	MIDDLE SCHOOL	.0000	.0000	10100.0
7	HIGH SCHOOL	.00[illegible]	.0000	10100.0
8	VILL OFFICE BLDG	.0000	.0000	10100.0
9	RECREATION CENTR	.0000	.0000	10100.0
10	SHOPPING CENTER	.0000	.0000	10100.0
11	COLLEGE	.0000	.0000	10100.0
12	SHOPPING MALL	.0000	.0000	10100.0
13	MALL RESTAURANT	.0000	.0000	10100.0
14	OFFICE BUILDING	.0000	.0000	10100.0
15	LO RISE INN	.0000	.0000	10100.0
16	HI RISE INN	.0000	.0000	10100.0
17	INN RESTAURANT	.0000	.0000	10100.0
18	HOSPITAL	.0000	.0000	10100.0
19	HI RISE APARTMNT	.0000	.0000	10100.0

	BUILDING	A/C CAPACITY TONS	A/C POWER KW	ANNUAL HEAT-MBTU	ELECTRICITY KWH X .0001	PERSONNEL MEN	CAPITAL $ X.001	MAINTAINENCE $ X.01
1	SINGLE FAMILY	41.90	.00	.00	.0000	.00	.197	.0985
2	TOWN HOUSE	41.90	.00	.00	.0000	.00	.120	.0600
3	GARDEN APARTMENT	20.00	.00	.00	.0000	.00	.036	.0180
4	ELEMENTRY SCHOOL	452.60	.00	.00	.0000	.00	1.393	.6960
5	VILL HI RISE APT	3746.70	.00	.00	.0000	.00	1.763	.8680
6	MIDDLE SCHOOL	3022.90	.00	.00	.0000	.00	1.763	.8680
7	HIGH SCHOOL	3022.90	.00	.00	.0000	.00	1.763	.8680
8	VILL OFFICE BLDG	574.87	.00	.00	.0000	.00	1.393	.6960
9	RECREATION CENTR	408.80	.00	.00	.0000	.00	1.393	.6960
10	SHOPPING CENTER	172.28	.00	.00	.0000	.00	.450	.2250
11	COLLEGE	180.00	.00	.00	.0000	.00	.495	.2475
12	SHOPPING MALL	574.00	.00	.00	.0000	.00	1.393	.6960
13	MALL RESTAURANT	.00	.00	.00	.0000	.00	1.299	.6500
14	OFFICE BUILDING	574.87	.00	.00	.0000	.00	1.393	.6960
15	LO RISE INN	3890.00	.00	.00	.0000	.00	2.600	1.3000
16	HI RISE INN	2882.00	.00	.00	.0000	.00	1.763	.8680
17	INN RESTAURANT	.00	.00	.00	.0000	.00	1.298	.6500
18	HOSPITAL	10723.70	.00	.00	.0000	.00	3.526	1.7600
19	HI RISE APARTMNT	3746.70	.00	.00	.0000	.00	1.763	.8680

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TABLE E-51.- Continued

(b) Input schedule array

1	713.00	713.00	1247.00	534.00	534.00	1071.00	534.00	534.00
	1071.00	534.00	534.00	1071.00	534.00	534.00	1071.00	534.00
	534.00	1247.00	713.00	713.00				
2	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
3	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
4	1.00	1.00	2.00	.00	1.00	2.00	.00	1.00
	2.00	.00	1.00	2.00	.00	1.00	2.00	.00
	1.00	2.00	1.00	1.00				
5	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	4.00	2.00	2.00				
6	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
7	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
8	.00	1.00	1.00	.00	1.00	1.00	.00	1.00
	1.00	.00	.00	1.00	1.00	.00	1.00	1.00
	1.00	1.00	1.00	1.00				
9	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
10	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
11	.00	.00	.00	1.00	.00	.00	.00	.00
	.00	.00	1.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
12	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	1.00	.00	.00	.00	.00	1.00	.00
	.00	.00	.00	.00				
13	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	1.00	.00	.00	.00	.00	1.00	.00
	.00	.00	.00	.00				
14	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	.00	.00	.00				
15	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.06	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
16	.00	.00	1.00	.00	.00	.00	1.00	.00
	1.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
17	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
18	.00	.00	.00	.00	.00	.50	.00	.00
	.00	.00	.00	.00	.00	.00	.50	.00
	.00	.00	.00	.00				
19	.00	.00	.00	.00	1.00	.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	.00	.00
	1.00	.00	.00	.00				

TABLE E-51.- Continued

(c) Total annual capital expenditures ($ x 10^{-5})

	BUILDING TYPE	1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	1.4046	1.4046	2.4566	1.0520	1.0520	2.1099	1.0520	1.0520	2.1099	1.0520
2	TOWN HOUSE	.3888	.3888	.6804	.2916	.2916	.5832	.2916	.2916	.5832	.2916
3	GARDEN APARTMENT	.1166	.1166	.2041	.0875	.0875	.1750	.0875	.0875	.1750	.0875
4	ELEMENTRY SCHOOL	.0139	.0139	.0279	.0000	.0139	.0279	.0000	.0139	.0279	.0000
5	VILL HI RISE APT	.0353	.0353	.0353	.0353	.0353	.0353	.0353	.0353	.0353	.0353
6	MIDDLE SCHOOL	.0000	.0176	.0000	.0176	.0000	.0176	.0000	.0000	.0176	.0000
7	HIGH SCHOOL	.0000	.0000	.0176	.0000	.0176	.0000	.0176	.0000	.0000	.0176
8	VILL OFFICE BLDG	.0000	.0139	.0139	.0000	.0139	.0139	.0000	.0139	.0139	.0000
9	RECREATION CENTR	.0000	.0139	.0000	.0139	.0000	.0139	.0000	.0000	.0139	.0000
10	SHOPPING CENTER	.0000	.0000	.0045	.0000	.0045	.0000	.0045	.0000	.0000	.0045
11	COLLEGE	.0000	.0000	.0000	.0049	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0139	.0000	.0000	.0000	.0000	.0139
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0130	.0000	.0000	.0000	.0000	.0130
14	OFFICE BUILDING	.0000	.0139	.0000	.0139	.0000	.0139	.0000	.0139	.0000	.0139
15	LO RISE INN	.0000	.0260	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HI RISE INN	.0000	.0000	.0176	.0000	.0000	.0000	.0176	.0000	.0176	.0000
17	INN RESTAURANT	.0000	.0130	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0176	.0000	.0000	.0000	.0000
19	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0176	.0000	.0000	.0000	.0176	.0000
	TOTAL	1.9592	2.0576	3.4579	1.5168	1.5609	3.0082	1.5061	1.5081	3.0119	1.5293

	BUILDING TYPE	11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	1.0520	2.1099	1.0520	1.0520	2.1099	1.0520	1.0520	2.4566	1.4046	1.4046	29.4909
2	TOWN HOUSE	.2916	.5832	.2916	.2916	.5832	.2916	.2916	.6804	.3888	.3888	8.1648
3	GARDEN APARTMENT	.0875	.1750	.0875	.0875	.1750	.0875	.0875	.2041	.1166	.1166	2.4494
4	ELEMENTRY SCHOOL	.0139	.0279	.0000	.0139	.0279	.0000	.0139	.0279	.0139	.0139	.2925
5	VILL HI RISE APT	.0353	.0353	.0353	.0353	.0353	.0353	.0353	.0705	.0353	.0353	.7405
6	MIDDLE SCHOOL	.0000	.0176	.0000	.0000	.0176	.0000	.0000	.0176	.0000	.0000	.1234
7	HIGH SCHOOL	.0000	.0000	.0176	.0000	.0000	.0176	.0000	.0000	.0176	.0000	.1234
8	VILL OFFICE BLDG	.0000	.0139	.0139	.0000	.0139	.0139	.0139	.0139	.0139	.0139	.1950
9	RECREATION CENTR	.0000	.0139	.0000	.0000	.0139	.0000	.0000	.0139	.0000	.0000	.0975
10	SHOPPING CENTER	.0000	.0000	.0045	.0000	.0000	.0045	.0000	.0000	.0045	.0000	.0315
11	COLLEGE	.0049	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0099
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0139	.0000	.0000	.0000	.0000	.0000	.0418
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0130	.0000	.0000	.0000	.0000	.0000	.0390
14	OFFICE BUILDING	.0000	.0139	.0000	.0139	.0000	.0139	.0000	.0000	.0000	.0000	.1114
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0260
16	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0529
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0130
18	HOSPITAL	.0000	.0000	.0000	.0000	.0176	.0000	.0000	.0000	.0000	.0000	.0353
19	HI RISE APARTMNT	.0000	.0176	.0000	.0000	.0000	.0000	.0176	.0000	.0000	.0000	.0705
	TOTAL	1.4852	3.0082	1.5029	1.4942	3.0212	1.5163	1.5118	3.4850	1.9953	1.9732	42.1087

ORIGINAL PAGE IS OF POOR QUALITY

TABLE E-51.- Continued

(d) Total annual maintenance costs ($ x 10^{-5})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.0702	.1905	.2633	.3159	.3685	.4740	.5266	.5792	.6847	.7373
2	TOWN HOUSE	.0194	.0389	.0729	.0875	.1021	.1312	.1458	.1604	.1895	.2041
3	GARDEN APARTMENT	.0058	.0117	.0219	.0262	.0306	.0394	.0437	.0481	.0569	.0612
4	ELEMENTRY SCHOOL	.0007	.0014	.0028	.0028	.0035	.0049	.0049	.0056	.0070	.0070
5	VILL HI RISE APT	.0017	.0035	.0052	.0069	.0087	.0104	.0122	.0139	.0156	.0174
6	MIDDLE SCHOOL	.0000	.0009	.0009	.0017	.0017	.0026	.0026	.0026	.0035	.0035
7	HIGH SCHOOL	.0000	.0000	.0009	.0009	.0017	.0017	.0026	.0026	.0026	.0035
8	VILL OFFICE BLDG	.0000	.0007	.0014	.0014	.0021	.0028	.0028	.0035	.0042	.0042
9	RECREATION CENTR	.0000	.0007	.0007	.0014	.0014	.0021	.0021	.0021	.0028	.0028
10	SHOPPING CENTER	.0000	.0000	.0002	.0002	.0004	.0004	.0007	.0007	.0007	.0009
11	COLLEGE	.0000	.0000	.0000	.0002	.0002	.0002	.0002	.0002	.0002	.0002
12	SHOPPING MALL'	.0000	.0000	.0000	.0000	.0007	.0007	.0007	.0007	.0007	.0014
13	HALL RESTAURANT	.0000	.0000	.0000	.0000	.0006	.0006	.0006	.0006	.0006	.0013
14	OFFICE BUILDING	.0000	.0007	.0007	.0014	.0014	.0021	.0021	.0028	.0028	.0035
15	LO RISE INN	.0000	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013
16	HI RISE INN	.0000	.0000	.0009	.0009	.0009	.0009	.0017	.0017	.0026	.0026
17	INN RESTAURANT	.0000	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006
18	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0009	.0009	.0009	.0009	.0009
19	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0009	.0009	.0009	.0009	.0017	.0017
	TOTAL	.0979	.2008	.3736	.4499	.5274	.6778	.7530	.8284	.9789	1.0553

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.7899	.8954	.9480	1.0006	1.1061	1.1587	1.2113	1.3341	1.4043	1.4795	15.4827
2	TOWN HOUSE	.2187	.2479	.2624	.2770	.3062	.3208	.3353	.3694	.3888	.4082	4.2865
3	GARDEN APARTMENT	.0656	.0744	.0787	.0831	.0919	.0962	.1006	.1108	.1166	.1225	1.2860
4	ELEMENTRY SCHOOL	.0077	.0090	.0090	.0097	.0111	.0111	.0118	.0132	.0139	.0146	.1517
5	VILL HI RISE APT	.0191	.0208	.0226	.0243	.0260	.0278	.0295	.0330	.0347	.0365	.3698
6	MIDDLE SCHOOL	.0035	.0043	.0043	.0043	.0052	.0052	.0052	.0061	.0061	.0061	.0703
7	HIGH SCHOOL	.0035	.0035	.0043	.0043	.0043	.0052	.0052	.0052	.0061	.0061	.0642
8	VILL OFFICE BLDG	.0042	.0049	.0056	.0056	.0063	.0070	.0077	.0084	.0090	.0097	.0912
9	RECREATION CENTR	.0028	.0035	.0035	.0035	.0042	.0042	.0042	.0049	.0049	.0049	.0564
10	SHOPPING CENTER	.0009	.0009	.0011	.0011	.0011	.0013	.0013	.0013	.0016	.0016	.0166
11	COLLEGE	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0067
12	SHOPPING MALL	.0014	.0014	.0014	.0014	.0021	.0021	.0021	.0021	.0021	.0021	.0230
13	HALL RESTAURANT	.0013	.0013	.0013	.0013	.0019	.0019	.0019	.0019	.0019	.0019	.0214
14	OFFICE BUILDING	.0035	.0042	.0042	.0049	.0049	.0056	.0056	.0056	.0056	.0056	.0668
15	LO RISE INN	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0247
16	HI RISE INN	.0026	.0026	.0026	.0026	.0026	.0026	.0026	.0026	.0026	.0026	.0382
17	INN RESTAURANT	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0123
18	HOSPITAL	.0009	.0009	.0009	.0009	.0018	.0018	.0018	.0018	.0018	.0018	.0185
19	HI RISE APARTMNT	.0017	.0026	.0026	.0026	.0026	.0026	.0035	.0035	.0035	.0035	.0356
	TOTAL	1.1296	1.2799	1.3550	1.4297	1.5807	1.6565	1.7320	1.9062	2.0059	2.1046	22.1227

TABLE E-51.- Concluded

(e) Delivered water (1000 gal x 10^{-5})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.2987	.5975	1.1200	1.3437	1.5675	2.0162	2.2400	2.4637	2.9125	3.1362
2	TOWN HOUSE	.1358	.2715	.5091	.6109	.7127	.9164	1.0182	1.1200	1.3236	1.4254
3	GARDEN APARTMENT	.0648	.1296	.2930	.2916	.3402	.4374	.4860	.5346	.6318	.6804
4	ELEMENTRY SCHOOL	.0045	.0091	.0181	.0181	.0226	.0317	.0317	.0362	.0453	.0453
5	VILL HI RISE APT	.0749	.1499	.2248	.2997	.3747	.4496	.5245	.5995	.6744	.7493
6	MIDDLE SCHOOL	.0000	.0302	.0302	.0605	.0605	.0907	.0907	.0907	.1209	.1209
7	HIGH SCHOOL	.0000	.0000	.0302	.0302	.0605	.0605	.0907	.0907	.0907	.1209
8	VILL OFFICE BLDG	.0000	.0057	.0115	.0115	.0172	.0230	.0230	.0287	.0345	.0345
9	RECREATION CENTR	.0000	.0041	.0041	.0082	.0082	.0123	.0123	.0123	.0164	.0164
10	SHOPPING CENTER	.0000	.0000	.0017	.0017	.0034	.0034	.0052	.0052	.0052	.0069
11	COLLEGE	.0000	.0000	.0000	.0018	.0018	.0018	.0018	.0018	.0018	.0018
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0057	.0057	.0057	.0057	.0057	.0115
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	OFFICE BUILDING	.0000	.0057	.0057	.0115	.0115	.0172	.0172	.0230	.0230	.0287
15	LO RISE INN	.0000	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389
16	HI RISE INN	.0000	.0000	.0288	.0288	.0288	.0288	.0576	.0576	.0865	.0865
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0536	.0536	.0536	.0536	.0536
19	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0375	.0375	.0375	.0375	.0749	.0749
	TOTAL	.5780	1.2922	2.2662	2.7572	3.2917	4.2247	4.7346	5.1997	6.1396	6.6322

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	3.3600	3.8087	4.0325	4.2562	4.7050	4.9287	5.1524	5.6749	5.9737	6.2724	65.8605
2	TOWN HOUSE	1.5273	1.7309	1.8327	1.9345	2.1382	2.2400	2.3418	2.5794	2.7151	2.8509	29.9342
3	GARDEN APARTMENT	.7290	.8262	.8748	.9234	1.0206	1.0692	1.1178	1.2312	1.2960	1.3608	14.2884
4	ELEMENTRY SCHOOL	.0498	.0588	.0588	.0634	.0724	.0724	.0769	.0860	.0905	.0950	.9867
5	VILL HI RISE APT	.8243	.8992	.9741	1.0491	1.1240	1.1989	1.2739	1.4237	1.4987	1.5736	15.9609
6	MIDDLE SCHOOL	.1209	.1511	.1511	.1511	.1814	.1814	.1814	.2116	.2116	.2116	2.4485
7	HIGH SCHOOL	.1209	.1209	.1511	.1511	.1511	.1814	.1814	.1814	.2116	.2116	2.2369
8	VILL OFFICE BLDG	.0345	.0402	.0460	.0460	.0517	.0575	.0632	.0690	.0747	.0805	.7531
9	RECREATION CENTR	.0164	.0204	.0204	.0204	.0245	.0245	.0245	.0286	.0286	.0286	.3311
10	SHOPPING CENTER	.0069	.0069	.0086	.0086	.0086	.0103	.0103	.0103	.0121	.0121	.1275
11	COLLEGE	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0486
12	SHOPPING MALL	.0115	.0115	.0115	.0115	.0172	.0172	.0172	.0172	.0172	.0172	.1894
13	MALL RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	OFFICE BUILDING	.0287	.0345	.0345	.0402	.0402	.0460	.0460	.0460	.0460	.0460	.5519
15	LO RISE INN	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.0389	.7391
16	HI RISE INN	.0865	.0865	.0865	.0865	.0865	.0865	.0865	.0865	.0865	.0865	1.2681
17	INN RESTAURANT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	HOSPITAL	.0536	.0536	.0536	.0536	.1072	.1072	.1072	.1072	.1072	.1072	1.1260
19	HI RISE APARTMNT	.0749	.1124	.1124	.1124	.1124	.1124	.1499	.1499	.1499	.1499	1.6361
	TOTAL	7.0876	8.0044	8.4912	8.9506	9.8836	10.3761	10.8730	11.9454	12.5619	13.1469	138.3871

TABLE E-52.- MIUS HOT-WATER SUBSYSTEM

(a) Component capital and maintenance costs

Building type	Sizing flow, gal/hr (1)	Recovery rate, gal/hr	Capital cost, 1973 $	Maintenance cost, 1973 $ (2)	Annual flow, gal	Comments
Garden apartment	5	8	36	1.80	20×10^3	Heat exchanger in tank
Townhouse	10	30	120	6.00	42	Heat exchanger in tank
Single family	10	30	197	9.85	42	Electric tank type
Village shopping center	33	45	450	22.50	172	Heat exchanger in tank, 1-in. supply
College	124	120	495	24.75	180	Heat exchanger in tank, 1-1/2-in. supply
Recreation center	134	500	1393	69.60	409	Components (size 2)
Office building (village and town center)	235	500	1393	69.60	575	Components (size 1)
Elementary school	247	500	1393	69.60	452	Components (size 2)
Shopping mall (3 phases, each phase)	332	500	1393	69.60	574	Components (size 2)
Three mall restaurants, each	115	167	1299	65.00	102	Components (size 1), 3 sets
High-rise apartment (village and town center)	961	1500	1763	86.80	3 747	Components (size 3)
Low-rise inn	946	1500	2600	130.00	2 882	Components (size 4), big pump and two tanks
Middle/high school	1434	2000	1763	86.80	3 023	Components (size 3)
High-rise inn	1277	2000	1763	86.80	3 890	Components (size 3)
Inn restaurant	694	1000	1298	65.00	2 555	Components (size 1)
Hospital	2265	4000	3526	176.00	10 724	Components (size 3), 2 sets

[1]During an average day, this is the maximum hot-water requirement during a 1-hour period.

[2]Repair, maintenance, and replacement cost; ref. E-14 provides between 3 and 8 percent, depending on the equipment. In the interest of time, 5 percent was used for all equipment in this study.

TABLE E-52.- Concluded

(b) Costs of component sizes

Component	Cost, $			
	Size 1	Size 2	Size 3	Size 4
Heat exchanger	360	402	709	492
Storage tank	847	895	895	[1]1424
Circulation pump	91.60	96	159	[1]234
Totals	1298.60	1393	1763	2600

[1]Two each.

TABLE E-53.- MIUS OPTION I WASTEWATER SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FØR
MIUS WASTE WATER SYSTEM - ØPTIØN I (11/30/73)

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	6.372	0.066	0.001	6.439	6.430	6.430
1976	1.652	0.272	0.006	1.931	1.647	8.078
1977	7.028	0.629	0.014	7.671	5.737	13.815
1978	0.250	0.939	0.022	1.211	0.714	14.528
1979	0.258	1.192	0.028	1.478	0.754	15.282
1980	7.511	1.445	0.035	8.991	4.374	19.656
1981	0.274	1.737	0.043	2.053	0.787	20.444
1982	0.282	2.033	0.051	2.366	0.787	21.231
1983	8.207	2.425	0.062	10.694	3.390	24.621
1984	0.299	2.840	0.074	3.213	0.805	25.426
1985	0.308	3.146	0.083	3.537	0.770	26.196
1986	8.968	3.515	0.095	12.578	2.602	28.799
1987	0.327	4.082	0.112	4.521	0.743	29.541
1988	0.337	4.317	0.121	4.774	0.682	30.223
1989	9.800	4.793	0.137	14.730	1.991	32.214
1990	0.357	5.243	0.152	5.753	0.621	32.834
1991	0.368	5.734	0.170	6.272	0.588	33.422
1992	10.835	6.087	0.184	17.105	1.514	34.936
1993	0.520	6.976	0.215	7.711	0.547	35.483
1994	0.536	7.473	0.235	8.243	0.509	35.992

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	47.105	64.488	24.835
LESS RESID. VALUE	31.294	46.088	2.816
NET CAPITAL CØSTS	15.811	18.399	22.019
CØSTS FØR FUEL	0.831	1.838	0.289
ØTHER ØP. CØSTS	0.00C	0.000	0.000
MAINTENANCE CØSTS	40.375	64.944	10.868
TØTAL CØSTS	57.017	85.182	33.176

CUMULATIVE SERVICE DELIVERED = 48.79100

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.965	1.322	0.509
LESS RESID. VALUE	0.641	0.945	0.058
NET CAPITAL CØSTS	0.324	0.377	0.451
CØSTS FØR FUEL	0.017	0.038	0.006
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.828	1.331	0.223
TØTAL CØSTS	1.169	1.746	0.680

TABLE E-53.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 11/30/73.

D. C. F. ANALYSIS FØR
MIUS WASTE WATER SYSTEM - ØPTIØN I (11/30/73)

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	6.372	0.066	0.002	6.440	6.431	6.431
1976	1.652	0.272	0.009	1.933	1.649	8.080
1977	7.028	0.629	0.022	7.680	5.743	13.823
1978	0.250	0.939	0.037	1.226	0.723	14.545
1979	0.258	1.192	0.053	1.503	0.766	15.312
1980	7.511	1.445	0.072	9.028	4.390	19.702
1981	0.274	1.737	0.096	2.107	0.807	20.509
1982	0.282	2.033	0.126	2.441	0.812	21.321
1983	8.207	2.425	0.168	10.800	3.420	24.741
1984	0.299	2.840	0.220	3.359	0.841	25.582
1985	0.308	3.146	0.271	3.725	0.811	26.393
1986	8.968	3.515	0.338	12.822	2.648	29.041
1987	0.327	4.082	0.439	4.848	0.796	29.837
1988	0.337	4.317	0.518	5.171	0.738	30.575
1989	9.800	4.793	0.641	15.234	2.053	32.628
1990	0.357	5.243	0.784	6.384	0.688	33.316
1991	0.368	5.734	0.957	7.059	0.661	33.977
1992	10.835	6.087	1.134	18.055	1.590	35.567
1993	0.520	6.976	1.451	8.948	0.634	36.201
1994	0.536	7.473	1.736	9.744	0.600	36.801

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	47.105	64.488	24.835
LESS RESID. VALUE	31.294	46.088	2.816
NET CAPITAL CØSTS	15.811	18.399	22.019
CØSTS FØR FUEL	0.831	9.075	1.098
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	40.375	64.944	10.868
TØTAL CØSTS	57.017	92.419	33.985

CUMULATIVE SERVICE DELIVERED = 48.79100

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.965	1.322	0.509
LESS RESID. VALUE	0.641	0.945	0.058
NET CAPITAL CØSTS	0.324	0.377	0.451
CØSTS FØR FUEL	0.017	0.186	0.023
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.828	1.331	0.223
TØTAL CØSTS	1.169	1.894	0.697

TABLE E-54.- MIUS OPTION I WASTEWATER SUBSYSTEM

(INPUTS TO DCP PROGRAM)

Year	Capital, 1973 $	Useful life, yr	Fuel, Btu (1)	O&M, 1973 $ (2)	Service delivered, gal
1975	4.756×10^6 1.250	30 75	1.218×10^9	0.0604×10^6	0.073×10^9
1976	1.189 .323	30 75	4.874	.242	.292
1977	4.756 1.488	30 75	10.944	.543	.656
1978	.216	75	15.856	.786	.950
1979	.216	75	19.527	.969	1.17
1980	4.756 1.351	30 75	23.032	1.141	1.38
1981	.216	75	26.870	1.331	1.61
1982	.216	75	30.543	1.513	1.83
1983	4.756 1.351	30 75	35.383	1.752	2.12
1984	.216	75	40.223	1.992	2.41
1985	.216	75	43.227	2.142	2.59
1986	4.756 1.351	30 75	46.899	2.324	2.81
1987	.216	75	52.907	2.62	3.17
1988	.216	75	54.243	2.69	3.25
1989	4.756 1.351	30 75	58.415	2.90	3.50
1990	.216	75	62.087	3.08	3.72
1991	.216	75	65.926	3.27	3.95
1992	4.756 1.423	30 75	67.928	3.37	4.07
1993	.288	75	75.606	3.75	4.53
1994	.288	75	78.610	3.90	4.71

[1]Fuel at 16.69 Btu/gal.

[2]Treatment plant O&M at 45.3¢/1000 gal; chemicals at 17.6¢/1000 gal; miscellaneous at 8.2¢/1000 gal; collection system O&M at 11.3¢/1000 gal.

TABLE E-55.- MIUS OPTION I WASTEWATER SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1966 $	Total capital cost	
			1966 $	1973 $
1975	Village A first-yr development:			
	Village center A submains			
	1500 ft of 8-in. sewer at $7/ft	10 500		
	1850 ft of 15-in. sewer at $10/ft	18 500		
	1100 ft of 18-in. sewer at $10.50/ft	11 500		
	550 ft of 24-in. sewer at $14/ft	7 700		
	Village center A laterals			
	1900 ft of 8-in. sewer at $7/ft	13 300		
	Village A manholes, mains and submains			
	94 manholes at $800 each	75 200		
	Village center A manholes			
	15 manholes at $400 each	6 000		
	Lift stations			
	Six, 8-in. submains	90 000		
	Three, 15-in. submains	150 000		
	MIUS lift stations			
	Four stations	80 000		
	Three neighborhood submains			
	21 120 ft of 8-in. sewer at $7/ft	147 840		
	3750 ft of 10-in. sewer at $8.25/ft	30 939		
	2100 ft of 15-in. sewer at $10/ft	21 000		
	Option I additive deltas			
	400 ft of 6-in. sewer at $5.75/ft	2 300		
	1200 ft of 8-in. sewer at $7/ft	8 400		
	7200 ft of 10-in. sewer at $8.25/ft	59 400		
	1000 ft of 12-in. sewer at $9/ft	9 000		
	Option II subtractive deltas			
	2750 ft of 15-in. sewer at $10/ft	-27 500		
	1100 ft of 18-in. sewer at $10.50/ft	-11 550		
	550 ft of 24-in. sewer at $14/ft	-7 700		
	Neighborhood development (A):			
	One-third of laterals, 25 700 ft of 8-in. sewer	179 900		
	96 manholes, one-third of total	38 400		
	Town center piping:			
	250 ft of 12-in. sewer at $9/ft	2 250		
	3100 ft of 15-in. sewer at $10/ft	31 000	0.946×10^6	1.249×10^6
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1976	Village A:			
	One-third of neighborhood development	218 300		
	Town center piping:			
	2500 ft of 18-in. sewer at $10.50/ft	26 250	.244	.323
	Treatment plant, 0.450×10^6 gal/day:			
	One plant	900 758	.901	1.189
1977	Village A:			
	One-third of neighborhood development	218 300		
	Village B first-yr development (same as village A 1975)	694 879		
	Neighborhood development (B):			
	One-fourth of laterals, 19 275 ft of 8-in. sewer	134 925		
	72 manholes, one-fourth of total	28 800		
	Town center piping:			
	4100 ft of 8-in. sewer at $7/ft	28 700		
	750 ft of 10-in. sewer at $8.25/ft	6 188		
	800 ft of 12-in. sewer at $9/ft	7 200		
	700 ft of 18-in. sewer at $10.50/ft	7 350	1.127	1.487
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1978	Village B:			
	One-fourth of neighborhood development	163 725	.164	.216
1979	Village B:			
	One-fourth of neighborhood development	163 725	.164	.216

Table E-55.- Concluded

Year	Description	Major component capital cost, 1966 $	Total capital cost	
			1966 $	1973 $
1980	Village B:			
	One-fourth of neighborhood development	163 725		
	Village C first-yr development	694 879		
	(same as village A 1975)			
	Neighborhood development (C)	163 725	1.022×10^6	1.349×10^6
	(same as 1977)			
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1981	Village C:			
	One-fourth of neighborhood development	163 725	.164	.216
1982	Village C:			
	One-fourth of neighborhood development	163 725	.164	.216
1983	Village C:			
	One-fourth of neighborhood development	163 725		
	Village D first-yr development	694 879		
	(same as village A 1975)			
	Neighborhood development (D)	163 725	1.022	1.349
	(same as 1977)			
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1984	Village D:			
	One-fourth of neighborhood development	163 725	.164	.216
1985	Village D:			
	One-fourth of neighborhood development	163 725	.164	.216
1986	Village D:			
	One-fourth of neighborhood development	163 725		
	Village E first-yr development	694 879		
	(same as village A 1975)			
	Neighborhood development (E)	163 725	1.022	1.349
	(same as 1977)			
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1987	Village E:			
	One-fourth of neighborhood development	163 725	.164	.216
1988	Village E:			
	One-fourth of neighborhood development	163 725	.164	.216
1989	Village E:			
	One-fourth of neighborhood development	163 725		
	Village F first-yr development			
	(same as village A 1975)	694 879		
	Neighborhood development (F)	163 725	1.022	1.349
	(same as 1977)			
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1990	Village F:			
	One-fourth of neighborhood development	163 725	.164	.216
1991	Village F:			
	One-fourth of neighborhood development	163 725	.164	.216
1992	Village F:			
	One-fourth of neighborhood development	163 725		
	Village G first-yr development	694 879		
	(same of village A 1975)			
	Neighborhood development (G)	218 300	1.077	1.422
	(same as 1975)			
	Treatment plant, 0.450×10^6 gal/day:			
	Four plants, $900 758 ea.	3 603 030	3.603	4.756
1993	Village G:			
	One-third of neighborhood development	218 300	.218	.288
1994	Village G:			
	One-third of neighborhood development	218 300	.218	.288

TABLE E-56.- MIUS OPTION I WASTEWATER SUBSYSTEM (COMPONENT CAPITAL COSTS)

Item description	Quantity	Unit cost, 1966 $	Total cost, 1966 $
Sewer:			
8-in.	723 840 ft	7.00	5 066 880
10-in.	77 400 ft	8.25	638 550
12-in.	8 050 ft	9.00	72 450
6-in.	2 800 ft	5.75	16 100
15-in.	11 500 ft	10.00	115 000
18-in.	3 200 ft	10.50	33 600
Manholes along mains	658	800.00	526 400
Other manholes	2 121	400.00	848 400
Lift stations, 8-in. mains	42	15 000.00	630 000
Lift stations, 15-in. mains	21	50 000.00	1 050 000
MIUS lift stations	28	20 000.00	560 000
Total collection system capital, 1966 $			9 557 000+
Total collection system capital, 1973 $			12 615 000+
Treatment plants (29 ea. at $1 189 000), 1973 $			34 481 000
Total capital cost, 1973 $			47 096 000

TABLE E-57.- MIUS OPTION I HVAC SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 12/ 4/73

D. C. F. ANALYSIS FØR
MIUS HVAC - ØPTIØN I - 12/4/73

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	5.079	0.176	0.000	5.256	5.233	5.233
1976	4.482	0.335	0.000	4.817	4.151	9.383
1977	6.817	0.638	0.000	7.455	5.574	14.958
1978	1.595	0.768	0.000	2.363	1.488	16.445
1979	2.553	0.940	0.000	3.493	1.927	18.372
1980	6.841	1.252	0.000	8.093	3.942	22.315
1981	1.734	1.410	0.000	3.143	1.279	23.594
1982	1.673	1.576	0.000	3.248	1.144	24.738
1983	11.121	1.955	0.000	13.076	4.191	28.929
1984	2.621	2.182	0.000	4.803	1.284	30.214
1985	1.722	2.379	0.000	4.101	0.937	31.151
1986	8.224	2.792	0.000	11.016	2.289	33.440
1987	2.153	3.020	0.000	5.173	0.893	34.333
1988	5.302	3.274	0.000	8.576	1.324	35.658
1989	10.139	3.784	0.000	13.923	1.898	37.556
1990	1.881	4.055	0.000	5.936	0.664	38.220
1991	2.192	4.340	0.000	6.532	0.638	38.858
1992	10.299	4.925	0.000	15.224	1.355	40.213
1993	2.558	5.296	0.000	7.855	0.579	40.792
1994	2.542	5.682	0.000	8.223	0.526	41.317

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	65.876	91.527	32.498
LESS RESID. VALUE	65.875	94.272	5.760
NET CAPITAL CØSTS	0.001	-2.745	26.738
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	31.730	50.777	8.819
TØTAL CØSTS	31.731	48.033	35.557

CUMULATIVE SERVICE DELIVERED = 1.58150

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	41.654	57.874	20.549
LESS RESID. VALUE	41.654	59.609	3.642
NET CAPITAL CØSTS	0.000	-1.736	16.907
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	20.063	32.107	5.577
TØTAL CØSTS	20.064	30.372	22.483

TABLE E-58.- MIUS OPTION I HVAC SUBSYSTEM (INPUTS TO THE DCF PROGRAM)

YEAR	CAPITAL (1973 $ x 10^{-6})	FUEL (BTU x 10^{-9})	ELECTRICITY (KWH x 10^{-6})	OTHER O-AND-M INCLUDING LABOR (1973 $ x 10^{-6})	MAN YEARS (O-AND-M)	A/C CAPACITY (TONS)
1975	4.7876	.00	.000	.1615	.00	12741.
1976	4.1018	.00	.000	.2974	.00	19864.
1977	6.0572	.00	.000	.5504	.00	34563.
1978	1.3758	.00	.000	.6430	.00	36699.
1979	2.1378	.00	.000	.7644	.00	38657.
1980	5.5621	.00	.000	.9883	.00	52472.
1981	1.3685	.00	.000	1.0804	.00	54608.
1982	1.2820	.00	.000	1.1725	.00	56566.
1983	8.2753	.00	.000	1.4122	.00	75454.
1984	1.8938	.00	.000	1.5301	.00	77056.
1985	1.2079	.00	.000	1.6198	.00	79014.
1986	5.6001	.00	.000	1.8456	.00	92829.
1987	1.4233	.00	.000	1.9383	.00	95054.
1988	3.4033	.00	.000	2.0402	.00	101106.
1989	6.3181	.00	.000	2.2895	.00	114921.
1990	1.1378	.00	.000	2.3819	.00	116523.
1991	1.2875	.00	.000	2.4749	.00	118481.
1992	5.8734	.00	.000	2.7271	.00	132824.
1993	1.4165	.00	.000	2.8470	.00	134963.
1994	1.3662	.00	.000	2.9653	.00	137102.

TABLE E-59.- MIUS HVAC SUBSYSTEM EQUIPMENT LIST

(a) MIUS options

Item description	Quantity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization
		Cost/unit	Total cost	Cost/unit	Total cost	Operating load, kW	Annual consumption, kWh	
Three-ton heat pump	1		1 540		154.00	5.37	16 760	Single family, common to all options
Outdoor unit		1 100				5.0		
Fan coil unit		410				.37		
Controls		30						
Fan coil unit	1		280		8.40	.37	3 240	Town house, MIUS I and II
Fan coil unit	1		223		6.70	.24	2 100	Garden apartments, MIUS I and II
Fan coil unit (6 zones)	1	6 220	6 250	188.00	191.00	10.8	94 610	Elementary school, MIUS I and II
Controls	1	30		3.00				
Fan coil units	2	10 593	21 186		962.00	60	525 600	Village high-rise apartments, MIUS I and II
Energy recovery, 41 450 ft³/min	1		6 310					
Total			27 496					
Fan coil units	3	13 232	39 696		1 538.00	78	683 280	Town center or village office building, MIUS I and II
Energy recovery, 28 440 ft³/min	1		4 260					
Total		43 956	43 956					
Fan coil units	1		10 593		519			Recreation center, MIUS I and II
Energy recovery 28 440 ft³/min	1		4 260					
Total			14 853					
Air handler with automatic roll	2	10 593	21 186		635			Middle school or high school, MIUS I and II
Air handlers	2	13 232	26 464		873			Village shopping center, MIUS I and II
Energy recovery 11 800 ft³/min	1		2 650					
Total			29 114					
Fan coil units	6	2 296	13 776	107.33	644	54	473 040	College, MIUS I and II
Air handling units with filters	20	4 000	800 000		27 000			Shopping mall, MIUS I and II
Air handling units with filters	5	7 320	36 200		1 290			High-rise inn, MIUS I and II
Air handling units with filters	3	6 560	19 700		1 000			Low-rise inn, MIUS I and II
Air handling units with filters	10	2 300	23 000		693			Hospital, MIUS I and II
Fan coil units	21	2 355	49 455	111.85	2 349	93.6	819 900	Town center high-rise apartments, MIUS I and II

TABLE E-59.- Continued

(b) Neighborhood MIUS

Item description	Quantity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization
		Cost/ unit	Total cost	Cost/ unit	Total cost	Operating load	Annual consumption, kWh	
738-ton absorption chiller	1	68 000			2380	160 kW 13 850 lb/hr		Option I only
906-ton compression chiller	1	56 500			1977	795 kW		
Cooling pond (150 by 100 by 4 ft)	1	33 600			1008			
125-hp hot-water boiler	2	12 340	24 680		617			
12-in. insulated pipe	2200	64.30	141 460					
3-in. gate valves	136	78.35	10 655		266			
Chilled-water pump, 3000 gal/min, 250 ft head	4	5 455	21 820		763			
Hot-water pumps 1670 gal/min, 90 ft head	3	4 422	13 266		464			
3-in. insulated pipe	1560	8.14	12 706					
1-1/4-in. insulated pipe	1800	4.65	8 370					
1-1/2-in. pipe	2000	5.02	10 040					
2-in. pipe	2640	5.77	15 232					
10-in. pipe	2840	45.46	129 106					
8-in. pipe	2860	28.17	80 566					
6-in. pipe	1840	18.36	33 782					
5-in. pipe	2480	15.01	37 224					
4-in. pipe	1600	10.86	17 376					
3-1/2-in. pipe	200	9.40	1 880					
Total			716 263		7475			

TABLE E-59.- Continued

(c) Village center MIUS

Item description	Quan-tity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization
		Cost/unit	Total cost	Cost/unit	Total cost	Operating load	Annual con-sumption	
1125-ton absorption chiller	3	76 000	228 000	2660	7980	53 480 lb/hr		Option I only
765-ton compression chiller	3	54 000	162 000	1890	5670	602 kW		
Cooling pond equipment	1	112 000			5760			
20-in. insulated pipe	2000	165	330 000					
3-in. gate valves	60	78.35	4 701		117			
Pump, 10 400 gal/min 400 hp	11	5 455	60 005		2100			
10-in. insulated pipe	3320	45.46	150 927					
Pump, 2400 gal/min, 400 hp	4	4 422	17 688		619			
16-in. pipe	300	122	36 600					
14-in. pipe	300	80.50	24 150					
12-in. pipe	820	64.30	52 726					
8-in. pipe	1800	28.17	50 706					
6-in. pipe	400	18.36	7 344					
5-in. pipe	2200	15.01	33 022					
4-in. pipe	1540	10.86	16 724					
3-1/2-in. pipe	200	9.40	1 880					
3-in. pipe	200	8.14	1 628					
2-1/2-in. pipe	2460	6.67	16 408					
2-in. pipe	700	5.77	4 039					
1-1/2-in. pipe	1200	5.02	6 024					
Total			1 316 572					

TABLE E-59.- Concluded

(d) Town center MIUS

Item description	Quantity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization (options I and II)
		Cost/unit	Total cost	Cost/unit	Total cost	Operating load	Annual consumption	
24-in. insulated pipe	25 940	187.00	4 850 780					Chilled water
20-in. insulated pipe	3 400	165.00	561 000					Chilled water
12-in. insulated pipe	18 020	64.30	1 158 686					Hot water
8-in. insulated pipe	18 760	28.17	528 469					Hot water
1660-ton absorption chiller	5	91 000	455 000		15 925	29 kW ea. 31 042 lb/hr ea.		
1900-ton compression chiller	5	117.500	587 500		20 662	1471 kW ea.		
Cooling pond (470 by 225 by 4 ft)	1	378 000			11 340			
Absorption water pumps, 12-in. suction, 8-in. discharge	5	4 220	21 100		633	186 kW ea.		
Compression water pumps, 12-in. suction, 8-in. discharge	5	4 220	21 100		633	186 kW ea.		
Hot-water pump, 6-in. suction, 4-in. discharge	3	1 735	5 205		156	93 kW ea.		
Incineration pump, 6-in. suction, 4-in. discharge	4	1 735	6 940		208	93 kW ea.		
18-in. pipe	1 140	135.00	153 900					
16-in. pipe	1 240	122.00	151 280					
14-in. pipe	540	80.50	43 470					
10-in. pipe	4 780	45.46	217 298					
6-in. pipe	6 500	18.36	119 340					
5-in. pipe	2 500	15.01	37 525					
4-in. pipe	700	10.86	7 602					
3-1/2-in. pipe	2 800	9.40	26 320					
3-in. pipe	9 200	8.14	74 888					
2-1/2-in. pipe	600	6.67	4 002					
2-in. pipe	800	5.77	4 616					
Total			9 414 012					

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TABLE E-60.- MIUS OPTION I HVAC SUBSYSTEM (ANNUAL CAPITAL AND O&M COSTS)

(a) Input data array

	BUILDING	ELECTRICAL RATE $/KWH	FUEL RATE $/MBTU	LABOR RATE $/MAN-YEAR
1	SINGLE FAMILY	.0000	.0000	10100.0
2	TOWN HOUSE	.0000	.0000	10100.0
3	GARDEN APARTMENT	.0000	.0000	10100.0
4	ELEMENTRY SCHOOL	.0000	.0000	10100.0
5	VILL HI RISE APT	.0000	.0000	10100.0
6	MIDDLE SCHOOL	.0000	.0000	10100.0
7	HIGH SCHOOL	.0000	.0000	10100.0
8	VILL OFFICE BLDG	.0000	.0000	10100.0
9	RECREATION CENTR	.0000	.0000	10100.0
10	SHOPPING CENTER	.0000	.0000	10100.0
11	COLLEGE	.0000	.0000	10100.0
12	SHOPPING MALL	.0000	.0000	10100.0
13	OFFICE BUILDING	.0000	.0000	10100.0
14	HI RISE INN	.0000	.0000	10100.0
15	LO RISE INN	.0000	.0000	10100.0
16	HOSPITAL	.0000	.0000	10100.0
17	HI RISE APARTMNT	.0000	.0000	10100.0
91	NEIGHBRHOOD MIUS	.0000	.0000	10100.0
92	VILLAGE MIUS	.0000	.0000	10100.0
93	TOWN CENTER MIUS	.0000	.0000	10100.0

	BUILDING	A/C CAPACITY TONS	A/C POWER KW	ANNUAL HEAT-MBTU	ELECTRICITY KWH X .0001	PERSONNEL MEN	CAPITAL $ X.001	MAINTAINENCE $ X.01
1	SINGLE FAMILY	3.00	.00	.00	.0000	.00	1.540	1.5400
2	TOWN HOUSE	.00	.00	.00	.0000	.00	.280	.0840
3	GARDEN APARTMENT	.00	.00	.00	.0000	.00	.223	.0670
4	ELEMENTRY SCHOOL	.00	.00	.00	.0000	.00	6.250	2.0600
5	VILL HI RISE APT	.00	.00	.00	.0000	.00	27.496	9.6200
6	MIDDLE SCHOOL	.00	.00	.00	.0000	.00	21.186	6.3500
7	HIGH SCHOOL	.00	.00	.00	.0000	.00	21.186	6.3500
8	VILL OFFICE BLDG	.00	.00	.00	.0000	.00	43.955	15.3800
9	RECREATION CENTR	.00	.00	.00	.0000	.00	19.853	5.1900
10	SHOPPING CENTER	.00	.00	.00	.0000	.00	29.114	8.7300
11	COLLEGE	.00	.00	.00	.0000	.00	13.776	6.4400
12	SHOPPING MALL	.00	.00	.00	.0000	.00	800.000	270.0000
13	OFFICE BUILDING	.00	.00	.00	.0000	.00	43.956	15.3800
14	HI RISE INN	.00	.00	.00	.0000	.00	36.200	12.9000
15	LO RISE INN	.00	.00	.00	.0000	.00	19.700	10.0000
16	HOSPITAL	.00	.00	.00	.0000	.00	23.000	6.9000
17	HI RISE APARTMNT	.00	.00	.00	.0000	.00	49.450	23.4900
91	NEIGHBRHOOD MIUS	1649.00	.00	.00	.0000	.00	716.263	74.7500
92	VILLAGE MIUS	5670.00	.00	.00	.0000	.00	1316.572	222.4600
93	TOWN CENTER MIUS	17800.00	.00	.00	.0000	.00	9419.012	495.5700

TABLE E-60.- Continued

(b) Input schedule array

1	713.00	713.00	1247.00	534.00	534.00	1071.00	534.00	534.00
	1071.00	534.00	534.00	1071.00	534.00	534.00	1071.00	534.00
	534.00	1247.00	713.00	713.00				
2	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
3	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
4	1.00	1.00	2.00	.00	1.00	2.00	.00	1.00
	2.00	.00	1.00	2.00	.00	1.00	2.00	.00
	1.00	2.00	1.00	1.00				
5	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	4.00	2.00	2.00				
6	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
7	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
8	.00	1.00	1.00	.00	1.00	1.00	.00	1.00
	1.00	.00	.00	1.00	1.00	.00	1.00	1.00
	1.00	1.00	1.00	1.00				
9	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
10	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
11	.00	.00	.00	1.00	.00	.00	.00	.00
	.00	.00	1.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
12	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	1.00	.00	.00	.00	.00	1.00	.00
	.00	.00	.00	.00				
13	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	.00	.00	.00				
14	.00	.00	1.00	.00	.00	.00	1.00	.00
	1.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
15	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
16	.00	.00	.00	.00	.00	.50	.00	.00
	.00	.00	.00	.00	.00	.00	.50	.00
	.00	.00	.00	.00				
17	.00	.00	.00	.00	1.00	.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	.00	.00
	1.00	.00	.00	.00				
21	3.00	.00	3.00	.00	.00	3.00	.00	.00
	3.00	.00	.00	3.00	.00	.00	3.00	.00
	.00	3.00	.00	.00				
22	1.00	.00	1.00	.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
23	.00	.28	.02	.03	.02	.00	.03	.02
	.29	.00	.02	.00	.04	.25	.00	.00
	.02	.00	.00	.00				

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TABLE E-60.- Continued

(c) Total annual capital expenditures ($\$ \times 10^{-6}$)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	1.0980	1.0980	1.9204	.8224	.8224	1.6493	.8224	.8224	1.6493	.8224
2	TOWN HOUSE	.0907	.0907	.1588	.0680	.0680	.1361	.0680	.0680	.1361	.0680
3	GARDEN APARTMENT	.0723	.0723	.1264	.0542	.0542	.1084	.0542	.0542	.1084	.0542
4	ELEMENTRY SCHOOL	.0062	.0062	.0125	.0000	.0062	.0125	.0000	.0062	.0125	.0000
5	VILL HI RISE APT	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.0550
6	MIDDLE SCHOOL	.0000	.0212	.0000	.0212	.0000	.0212	.0000	.0000	.0212	.0000
7	HIGH SCHOOL	.0000	.0000	.0212	.0000	.0212	.0000	.0212	.0000	.0000	.0212
8	VILL OFFICE BLDG	.0000	.0440	.0440	.0000	.0440	.0440	.0000	.0440	.0440	.0000
9	RECREATION CENTR	.0000	.0149	.0000	.0149	.0000	.0149	.0000	.0000	.0149	.0000
10	SHOPPING CENTER	.0000	.0000	.0291	.0000	.0291	.0000	.0291	.0000	.0000	.0291
11	COLLEGE	.0000	.0000	.0000	.0138	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.8000	.0000	.0000	.0000	.0000	.8000
13	OFFICE BUILDING	.0000	.0440	.0000	.0440	.0000	.0440	.0000	.0440	.0000	.0440
14	HI RISE INN	.0000	.0000	.0362	.0000	.0000	.0000	.0362	.0000	.0362	.0000
15	LO RISE INN	.0000	.0197	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0115	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0494	.0000	.0000	.0000	.0494	.0000
91	NEIGHBORHOOD MIUS	2.1488	.0000	2.1488	.0000	.0000	2.1488	.0000	.0000	2.1488	.0000
92	VILLAGE MIUS	1.3166	.0000	1.3166	.0000	.0000	1.3166	.0000	.0000	1.3166	.0000
93	TOWN CENTER MIUS	.0000	2.6359	.1883	.2824	.1883	.0000	.2824	.1883	2.6830	.0000
	TOTAL	4.7876	4.1018	6.0572	1.3758	2.1378	5.5621	1.3685	1.2820	8.2753	1.8938

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.8224	1.6493	.8224	.8224	1.6493	.8224	.8224	1.9204	1.0980	1.0980	23.0538
2	TOWN HOUSE	.0680	.1361	.0680	.0680	.1361	.0680	.0680	.1588	.0907	.0907	1.9051
3	GARDEN APARTMENT	.0542	.1084	.0542	.0542	.1084	.0542	.0542	.1264	.0723	.0723	1.5173
4	ELEMENTRY SCHOOL	.0062	.0125	.0000	.0062	.0125	.0000	.0062	.0125	.0062	.0062	.1312
5	VILL HI RISE APT	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.1100	.0550	.0550	1.1548
6	MIDDLE SCHOOL	.0000	.0212	.0000	.0000	.0212	.0000	.0000	.0212	.0000	.0000	.1483
7	HIGH SCHOOL	.0000	.0000	.0212	.0000	.0000	.0212	.0000	.0000	.0212	.0000	.1483
8	VILL OFFICE BLDG	.0000	.0440	.0440	.0000	.0440	.0440	.0440	.0440	.0440	.0440	.4154
9	RECREATION CENTR	.0000	.0149	.0000	.0000	.0149	.0000	.0000	.0149	.0000	.0000	.1040
10	SHOPPING CENTER	.0000	.0000	.0291	.0000	.0000	.0291	.0000	.0000	.0291	.0000	.2038
11	COLLEGE	.0138	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0276
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.8000	.0000	.0000	.0000	.0000	.0000	2.4000
13	OFFICE BUILDING	.0000	.0440	.0000	.0440	.0000	.0440	.0000	.0000	.0000	.0000	.3516
14	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.1086
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0197
16	HOSPITAL	.0000	.0000	.0000	.0000	.0115	.0000	.0000	.0000	.0000	.0000	.0230
17	HI RISE APARTMNT	.0000	.0494	.0000	.0000	.0000	.0000	.0494	.0000	.0000	.0000	.1978
91	NEIGHBORHOOD MIUS	.0000	2.1488	.0000	.0000	2.1488	.0000	.0000	2.1488	.0000	.0000	15.0415
92	VILLAGE MIUS	.0000	1.3166	.0000	.0000	1.3166	.0000	.0000	1.3166	.0000	.0000	9.2160
93	TOWN CENTER MIUS	.1883	.0000	.3295	2.3535	.0000	.0000	.1883	.0000	.0000	.0000	9.5082
	TOTAL	1.2079	5.6001	1.4233	3.4033	6.318	1.1378	1.2875	5.8734	1.4165	1.3662	65.8760

TABLE E-60.- Continued

(d) Total annual O&M costs ($ x 10^{-6})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.1098	.2196	.4116	.4939	.5761	.7410	.8233	.9055	1.0705	1.1527
2	TOWN HOUSE	.0027	.0054	.0102	.0122	.0143	.0184	.0204	.0225	.0265	.0286
3	GARDEN APARTMENT	.0022	.0043	.0081	.0098	.0114	.0147	.0163	.0179	.0212	.0228
4	ELEMENTARY SCHOOL	.0002	.0004	.0008	.0008	.0010	.0014	.0014	.0016	.0021	.0021
5	VILL HI RISE APT	.0019	.0038	.0058	.0077	.0096	.0115	.0135	.0154	.0173	.0192
6	MIDDLE SCHOOL	.0000	.0006	.0006	.0013	.0013	.0019	.0019	.0019	.0025	.0025
7	HIGH SCHOOL	.0000	.0000	.0006	.0006	.0013	.0013	.0019	.0019	.0019	.0025
8	VILL OFFICE BLDG	.0000	.0015	.0031	.0031	.0046	.0062	.0062	.0077	.0092	.0092
9	RECREATION CENTR	.0000	.0005	.0005	.0010	.0010	.0016	.0016	.0016	.0021	.0021
10	SHOPPING CENTER	.0000	.0000	.0009	.0009	.0017	.0017	.0026	.0026	.0026	.0035
11	COLLEGE	.0000	.0000	.0060	.0006	.0006	.0006	.0006	.0006	.0006	.0006
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0270	.0270	.0270	.0270	.0270	.0540
13	OFFICE BUILDING	.0000	.0015	.0015	.0031	.0031	.0046	.0046	.0062	.0062	.0077
14	HI RISE INN	.0000	.0000	.0013	.0013	.0013	.0013	.0026	.0026	.0039	.0039
15	LO RISE INN	.0000	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0003	.0003	.0003	.0003	.0003
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0023	.0023	.0023	.0023	.0047	.0047
91	NEIGHBRHOOD MIUS	.0224	.0224	.0440	.0448	.0448	.0673	.0673	.0673	.0897	.0897
92	VILLAGE MIUS	.0222	.0222	.0445	.0485	.0445	.0667	.0667	.0667	.0890	.0890
93	TOWN CENTER MIUS	.0000	.0139	.0149	.0169	.0173	.0173	.0188	.0198	.0339	.0339
	TOTAL	.1615	.2974	.5504	.6430	.7649	.9883	1.0804	1.1725	1.4122	1.5301

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	1.2349	1.3999	1.4821	1.5643	1.7293	1.8115	1.8937	2.0858	2.1956	2.3054	24.2065
2	TOWN HOUSE	.0306	.0347	.0367	.0388	.0429	.0449	.0469	.0517	.0544	.0572	.6001
3	GARDEN APARTMENT	.0244	.0277	.0293	.0309	.0342	.0358	.0374	.0412	.0434	.0456	.4787
4	ELEMENTARY SCHOOL	.0023	.0027	.0027	.0029	.0033	.0033	.0035	.0039	.0041	.0043	.0449
5	VILL HI RISE APT	.0212	.0231	.0250	.0269	.0289	.0308	.0327	.0366	.0385	.0404	.4098
6	MIDDLE SCHOOL	.0025	.0032	.0032	.0032	.0038	.0038	.0038	.0044	.0044	.0044	.0514
7	HIGH SCHOOL	.0025	.0025	.0032	.0032	.0032	.0038	.0038	.0038	.0044	.0044	.0470
8	VILL OFFICE BLDG	.0092	.0108	.0123	.0123	.0138	.0154	.0169	.0185	.0200	.0215	.2015
9	RECREATION CENTR	.0021	.0026	.0026	.0026	.0031	.0031	.0031	.0036	.0036	.0036	.0420
10	SHOPPING CENTER	.0035	.0035	.0044	.0044	.0044	.0052	.0052	.0052	.0061	.0061	.0646
11	COLLEGE	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0174
12	SHOPPING MALL	.0540	.0540	.0540	.0540	.0810	.0810	.0810	.0810	.0810	.0810	.8910
13	OFFICE BUILDING	.0077	.0092	.0092	.0108	.0108	.0123	.0123	.0123	.0123	.0123	.1476
14	HI RISE INN	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0568
15	LO RISE INN	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0190
16	HOSPITAL	.0003	.0003	.0003	.0003	.0007	.0007	.0007	.0007	.0007	.0007	.0072
17	HI RISE APARTMNT	.0047	.0070	.0070	.0070	.0070	.0070	.0094	.0094	.0094	.0094	.0763
91	NEIGHBRHOOD MIUS	.0897	.1121	.1121	.1121	.1345	.1345	.1345	.1570	.1570	.1570	1.8613
92	VILLAGE MIUS	.0890	.1112	.1112	.1112	.1335	.1335	.1335	.1557	.1557	.1557	1.8464
93	TOWN CENTER MIUS	.0349	.0349	.0367	.0491	.0491	.0491	.0501	.0501	.0501	.0501	.6403
	TOTAL	1.6198	1.8456	1.9383	2.0802	2.2895	2.3819	2.4744	2.7271	2.8470	2.9653	31.7298

TABLE E-60.- Concluded

(e) On-line tons of air-conditioning (ton x 10^{-4})

BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1 SINGLE FAMILY	.2139	.4278	.8019	.9621	1.1223	1.4436	1.6038	1.7640	2.0853	2.2455
2 TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3 GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4 ELEMENTRY SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5 VILL HI RISE APT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6 MIDDLE SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7 HIGH SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8 VILL OFFICE BLDG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9 RECREATION CENTR	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10 SHOPPING CENTER	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11 COLLEGE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12 SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13 OFFICE BUILDING	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14 HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15 LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16 HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17 HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
91 NEIGHBRHOOD MIUS	.4932	.4932	.9864	.9864	.9864	1.4796	1.4796	1.4796	1.9728	1.9728
92 VILLAGE MIUS	.5670	.5670	1.1340	1.1340	1.1340	1.7010	1.7010	1.7010	2.2680	2.2680
93 TOWN CENTER MIUS	.0000	.4984	.5380	.5874	.6230	.6230	.6769	.7120	1.2193	1.2193
TOTAL	1.2741	1.9864	3.4563	3.6699	3.8657	5.2472	5.4608	5.6566	7.5454	7.7056

BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1 SINGLE FAMILY	2.4057	2.7270	2.8872	3.0474	3.3687	3.5289	3.6891	4.0632	4.2771	4.4910	47.1555
2 TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3 GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4 ELEMENTRY SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5 VILL HI RISE APT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6 MIDDLE SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7 HIGH SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8 VILL OFFICE BLDG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9 RECREATION CENTR	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10 SHOPPING CENTER	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11 COLLEGE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12 SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13 OFFICE BUILDING	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14 HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15 LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16 HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17 HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
91 NEIGHBRHOOD MIUS	1.9728	2.4660	2.4660	2.4660	2.9592	2.9592	2.9592	3.4524	3.4524	3.4524	40.9356
92 VILLAGE MIUS	2.2680	2.8350	2.8350	2.8350	3.4020	3.4020	3.4020	3.9690	3.9690	3.9690	47.0610
93 TOWN CENTER MIUS	1.2549	1.2549	1.3172	1.7622	1.7622	1.7622	1.7978	1.7978	1.7978	1.7978	22.9976
TOTAL	7.9014	9.2829	9.5054	10.1106	11.4921	11.6523	11.8481	13.2824	13.4963	13.7102	158.1497

TABLE E-61.- MIUS SOLID-WASTE SUBSYSTEM COSTS (DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FØR
MIUS SØLID WASTE SUBSYSTEM (USED FØR BØTH ØPTIØNS) 12/3/73

COST FLOW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	0.508	0.122	0.017	0.647	0.629	0.629
1976	0.474	0.251	0.030	0.755	0.624	1.254
1977	0.593	0.449	0.064	1.106	0.786	2.039
1978	0.632	0.602	0.089	1.323	0.811	2.850
1979	0.283	0.719	0.112	1.114	0.575	3.425
1980	0.607	0.883	0.133	1.623	0.741	4.166
1981	0.378	1.069	0.171	1.617	0.629	4.795
1982	0.734	1.183	0.191	2.107	0.725	[illegible]
1983	1.300	1.397	0.236	2.933	0.889	6.409
1984	0.558	1.574	0.273	2.406	0.615	7.024
1985	0.500	1.753	0.314	2.567	0.568	7.592
1986	0.855	1.959	0.370	3.184	0.619	8.212
1987	0.582	2.130	0.407	3.118	0.521	8.733
1988	1.243	2.401	0.446	4.089	0.604	9.337
1989	0.971	2.641	0.514	4.127	0.525	9.862
1990	0.711	2.843	0.572	4.126	0.452	10.314
1991	0.865	3.088	0.619	4.573	0.437	10.751
1992	1.531	3.473	0.730	5.734	0.482	11.233
1993	0.966	3.767	0.801	5.534	0.399	11.632
1994	0.831	4.054	0.874	5.759	0.359	11.992

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	10.461	15.123	4.485
LESS RESID. VALUE	5.151	8.067	0.493
NET CAPITAL CØSTS	5.309	7.055	3.992
CØSTS FØR FUEL	3.165	6.963	1.121
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	22.765	36.358	6.386
TØTAL CØSTS	31.239	50.376	11.499

CUMULATIVE SERVICE DELIVERED = 1.53050

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.835	9.881	2.930
LESS RESID. VALUE	3.366	5.271	0.322
NET CAPITAL CØSTS	3.469	4.610	2.608
CØSTS FØR FUEL	2.068	4.550	0.732
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	14.874	23.756	4.172
TØTAL CØSTS	20.411	32.915	7.513

TABLE E-61.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FØR
MIUS SØLID WASTE SUBSYSTEM (USED FØR BØTH ØPTIØNS) 12/3/73

COST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	0.508	0.122	0.022	0.653	0.634	0.634
1976	0.474	0.251	0.043	0.768	0.634	1.268
1977	0.593	0.449	0.100	1.142	0.810	2.078
1978	0.632	0.602	0.153	1.387	0.847	2.925
1979	0.283	0.719	0.212	1.214	0.625	3.550
1980	0.607	0.883	0.276	1.765	0.803	4.353
1981	0.378	1.069	0.387	1.834	0.711	5.063
1982	0.734	1.183	0.473	2.390	0.817	5.880
1983	1.300	1.397	0.643	3.340	1.005	6.885
1984	0.558	1.574	0.814	2.947	0.749	7.634
1985	0.500	1.753	1.025	3.278	0.721	8.355
1986	0.855	1.959	1.323	4.137	0.797	9.152
1987	0.582	2.130	1.593	4.304	0.714	9.866
1988	1.243	2.401	1.910	5.554	0.811	10.677
1989	0.971	2.641	2.415	6.027	0.759	11.436
1990	0.711	2.843	2.942	6.496	0.706	12.141
1991	0.865	3.088	3.488	7.442	0.704	12.845
1992	1.531	3.473	4.504	9.508	0.787	13.632
1993	0.966	3.767	5.412	10.145	0.723	14.355
1994	0.831	4.054	6.467	11.352	0.701	15.056

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	10.461	15.123	4.485
LESS RESID. VALUE	5.151	8.067	0.493
NET CAPITAL CØSTS	5.309	7.055	3.992
CØSTS FØR FUEL	3.165	34.202	4.185
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	22.765	36.358	6.386
TØTAL CØSTS	31.239	77.615	14.563
CUMULATIVE SERVICE DELIVERED =		1.53050	

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.835	9.881	2.930
LESS RESID. VALUE	3.366	5.271	0.322
NET CAPITAL CØSTS	3.469	4.610	2.608
CØSTS FØR FUEL	2.068	22.347	2.734
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	14.874	23.756	4.172
TØTAL CØSTS	20.411	50.712	9.515

TABLE E-62.- MIUS OPTIONS I AND II SOLID-WASTE SUBSYSTEM (INPUTS TO DCP PROGRAM)

Year	Capital, 1973 $ (1)	Fuel, Btu	Maintenance labor and material, 1973 $ (2)	Operator labor, 1973 $ (3)	Total O&M, 1973 $ (4)	Annual service, tons
1975	0.4789×10^6	14.4×10^9	0.022×10^6	0.090×10^6	0.112×10^6	0.55×10^4
1976	.4335	24.1	.043	.180	.223	1.09
1977	.5273	48.9	.067	.320	.387	2.31
1978	.5453	65.0	.094	.410	.504	2.96
1979	.2370	78.0	.105	.480	.585	3.64
1980	.4601	88.4	.127	.570	.697	4.72
1981	.2622	107.8	.129	.680	.819	5.12
1982	.4230	114.7	.160	.720	.880	5.54
1983	.8208	135.4	.199	.810	1.009	6.61
1984	.3198	149.2	.214	.890	1.104	7.24
1985	.2299	163.3	.224	.970	1.194	7.95
1986	.4428	183.3	.245	1.05	1.295	9.04
1987	.2522	191.9	.247	1.11	1.367	9.45
1988	.5939	200.1	.286	1.21	1.496	9.83
1989	.4428	220.0	.308	1.29	1.598	10.90
1990	.2627	233.1	.320	1.35	1.670	11.60
1991	.2479	240.3	.331	1.43	1.761	12.45
1992	.6689	269.8	.363	1.56	1.923	13.45
1993	.2624	281.9	.375	1.65	2.025	14.02
1994	.2415	292.9	.386	1.73	2.116	14.58

[1]See detailed equipment list for component costs.
[2]Maintenance labor and materials at 5 percent of capital value.
[3]Operator labor at $10 000/yr.
[4]Not including fuel and electricity.

C.6

TABLE E-63.- MIUS SOLID-WASTE SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	1	Pushcart, 1-yd^3, at $140 ea.	5	140	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	2	Gravity chute systems at $350/floor plus $350			
		Two 12-story systems	40	9 100	
	1	Packer truck, 40-yd^3	7	35 000	
	12	Blue Boxes, 10-yd^3, at $600 ea.	5	7 200	
	1	Compactor container, 40-yd^3	5	7 500	
	2	Compactor containers, 10-yd^3 at $6000 ea.	5	12 000	
	1	Front-end loader, 40-yd^3	7	35 000	
	2	Trucks for compactor container, at $3500	7	7 000	
	1	Tractor crawler	8	8 000	
	1	Steel-wheeled compactor	8	8 000	
	2	Incinerators, at $170 000 ea.	30	340 000	0.4789×10^6
1976	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd^3	5	35 000	
	10	Blue Boxes, 10-yd^3, at $600 ea.	5	6 000	
	4	Compactor containers, 10-yd^3, at $6000 ea.	5	24 000	
	2	Incinerators at $170 000	30	340 000	.4335
1977	3	Pushcarts, 1-yd^3, at $140 ea.	5	420	
	8	Satellite vehicles, 2-yd^3, at $2500 ea.	5	20 000	
	8	Gravity chute systems at $350/floor plus $350			
		Seven 12-story systems	40	31 850	
		One 22-story system	40	8 050	
	2	Packer trucks, 40-yd^3, at $35 000 ea.	7	70 000	
	13	Blue Boxes, 10-yd^3, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd^3	5	7 500	
	7	Compactor containers, 10-yd^3, at $6000 ea.	5	42 000	
	2	Incinerators at $170 000 ea.	30	340 000	.5276
1978	1	Pushcart, 1-yd^3	5	140	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd^3	7	35 000	
	9	Blue Boxes, 10-yd^3, at $600 ea.	5	5 400	
	8	Compactor containers, 10-yd^3, at $6000 ea.	5	48 000	
	1	Truck for compactor container hauling	7	3 500	
	1	Scraper	8	12 000	
	1	Dragline	8	20 000	
	1	Water truck	8	4 500	
	2	Incinerators, at $170 000 ea.	30	340 000	.4967

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-63.- Continued

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
1979	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	2	Gravity chute systems at $350/floor plus $350			
		Two 12-story systems	40	9 100	
	1	Packer truck, 40-yd³	7	35 000	
	1	Blue Box, 10-yd³	5	600	
	2	Compactor containers, 10-yd³, at $6000 ea.	5	12 000	
	1	Incinerator	30	170 000	0.2370×10^6
1980	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	5	Gravity chute systems at $350/floor plus $350			
		Five 12-story systems	40	22 750	
	1	Packer truck, 40-yd³	7	35 000	
	16	Blue Boxes, 10-yd³, at $600 ea.	5	9 600	
	2	Compactor containers, 40-yd³, at $7500 ea.	5	15 000	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	1	Truck for compactor container hauling	7	3 500	
	2	Incinerators, at $170 000 each	30	340 000	.4601
1981	1	Pushcart, 1-yd³	5	140	
	8	Satellite vehicles, 2-yd³, at $2500 ea.	5	20 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd³	7	35 000	
	9	Blue Boxes, 10-yd³, at $600 ea.	5	5 400	
	3	Compactor containers, 10-yd³, at $6000 ea.	5	18 000	
	1	Incinerator	30	170 000	.2622
1982	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	3	Gravity chute systems at $350/floor plus $350			
		Two 12-story systems	40	9 100	
		One 22-story system	40	8 050	
	1	Packer truck, 40-yd³	7	35 000	
	1	Blue Box, 10-yd³	5	600	
	5	Compactor containers, 10-yd³, at $6000 ea.	5	30 000	
	2	Incinerators, at $170 000	30	340 000	.4230
1983	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	5	Gravity chute systems at $350/floor plus $350			
		Five 12-story systems	40	22 750	
	1	Packer truck, 40-yd³	7	35 000	
	13	Blue Boxes, 10-yd³, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd³	5	7 500	

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE B-63.- Continued

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
	9	Compactor containers, 10-yd³, at $6000 ea.	5	54 000	
	1	Truck for compactor container hauling	7	3 500	
	4	Incinerators, at $170 000 ea.	30	680 000	0.8208×10^6
1984	1	Pushcart, 1-yd³	5	140	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	5	Gravity chute systems at $350/floor plus $350			
		One 22-story system	40	8 050	
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd³	7	35 000	
	9	Blue Boxes, 10-yd³, at $600 ea.	5	5 400	
	5	Compactor containers, 10-yd³, at $6000 ea.	5	30 000	
	1	Front-end loader, 40-yd³	7	35 000	
	1	Tractor crawler	8	8 000	
	1	Incinerator	30	170 000	.3198
1985	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	1	Gravity chute system at $350/floor plus $350			
		One 12-story system	40	4 550	
	1	Packer truck, 40-yd³	5	35 000	
	1	Blue Box, 10-yd³	5	600	
	1	Compactor container, 10-yd³	5	6 000	
	1	Truck for compactor container hauling	7	3 500	
	1	Incinerator	30	170 000	.2299
1986	2	Pushcarts, 1-yd³, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd³	7	35 000	
	13	Blue Boxes, 10-yd³, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd³	5	7 500	
	4	Compactor containers, 10-yd³, at $6000 ea.	5	24 000	
	2	Incinerators, at $170 000 ea.	30	340 000	.4428
1987	1	Pushcart, 1-yd³	5	140	
	4	Satellite vehicles, 2-yd³, at $2500 ea.	5	10 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd³	7	35 000	
	9	Blue Boxes, 10-yd³, at $600 ea.	5	5 400	
	3	Compactor containers, 10-yd³, at $6000 ea.	5	18 000	
	1	Incinerator	30	170 000	.2522
1988	2	Pushcarts, 1-yd³, at $140 ea.	5	280	

[1] A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-63.- Continued

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	1	Gravity chute system at $350/floor plus $350			
		One 12-story system	40	4 550	
	1	Packer truck, 40-yd^3	7	35 000	
	1	Blue Box, 10-yd^3	5	600	
	5	Compactor containers, 10-yd^3, at $6000 ea.	5	30 000	
	1	Truck for compactor container hauling	7	3 500	
	3	Incinerators, at $170 000 ea.	30	510 000	0.5939×10^6
1989	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck, 40-yd^3	7	35 000	
	13	Blue Boxes, 10-yd^3, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd^3	5	7 500	
	4	Compactor containers 10-yd^3, at $6000 ea.	5	24 000	
	2	Incinerators, at $170 000	30	340 000	.4428
1990	1	Pushcart, 1-yd^3	5	140	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	4	Gravity chute systems at $350/floor plus $350			
		Four 12-story systems	40	18 200	
	1	Packer truck	7	35 000	
	9	Blue Boxes, 10-yd^3, at $600 ea.	5	5 400	
	4	Compactor containers, 10-yd^3, at $6000 ea.	5	24 000	
	1	Incinerator	30	170 000	.2627
1991	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	1	Gravity chute system at $350/floor plus $350			
		One 12-story system	40	4 550	
	1	Packer truck, 40-yd^3	7	35 000	
	1	Blue Box, 10-yd^3	5	600	
	4	Compactor containers, 10-yd^3, at $6000 ea.	5	24 000	
	1	Truck for compactor container hauling	7	35 000	
	1	Incinerator	30	170 000	.2794
1992	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	8	Satellite vehicles, 2-yd^3, at $2500 ea.	5	20 000	
	7	Gravity chute systems at $350/floor plus $350			
		One 22-story system	40	8 050	
		Six 12-story systems	40	27 300	
	2	Packer trucks, 40-yd^3, at $35 000 ea.	7	70 000	
	13	Blue Boxes, 10-yd^3, at $600 ea.	5	7 800	
	1	Compactor container, 40-yd^3	5	7 500	

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-63.- Concluded

Year	Quantity	Description	Useful life, yr (1)	Major component capital cost, 1973 $	Total capital cost, 1973 $
	3	Compactor containers, 10-yd^3, at $6000 ea.	5	18 000	
	3	Incinerators, at $170 000 ea.	30	510 000	0.6689×10^{6}
1993	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd^3	7	35 000	
	10	Blue Boxes, 10-yd^3, at $600 ea.	5	6 000	
	4	Compactor containers, 10-yd^3, at $6000 ea.	5	24 000	
	1	Truck for compactor container hauling	7	3 500	
	1	Incinerator	30	170 000	.2624
1994	2	Pushcarts, 1-yd^3, at $140 ea.	5	280	
	4	Satellite vehicles, 2-yd^3, at $2500 ea.	5	10 000	
	3	Gravity chute systems at $350/floor plus $350			
		Three 12-story systems	40	13 650	
	1	Packer truck, 40-yd^3	7	35 000	
	1	Blue Box, 10-yd^3	5	600	
	2	Compactor containers, 10-yd^3, at $6000 ea.	5	12 000	
	1	Incinerator	30	170 000	.2415

[1]A salvage value of 10 percent of the initial cost of all equipment with a useful life of less than 20 years was assumed. Replacement costs of this equipment are not reflected in this table but are reflected in the outputs from the discounted cash analysis program.

TABLE E-64.- MIUS OPTION I CONTROLS SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01758 DOLLARS PER KWH
THIS RUN MADE 11/ 5/73

D. C. F. ANALYSIS FOR
MIUS CONTROLS SYSTEM, OPTION I - 8/8/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	1.778	0.215	0.000	1.993	1.965	1.965
1976	0.409	0.256	0.000	0.665	0.549	2.514
1977	1.605	0.443	0.000	2.048	1.505	4.019
1978	0.000	0.457	0.000	0.457	0.261	4.281
1979	0.000	0.470	0.000	0.470	0.234	4.514
1980	1.754	0.681	0.000	2.435	1.166	5.681
1981	0.000	0.701	0.000	0.701	0.264	5.944
1982	0.000	0.722	0.000	0.722	0.236	6.181
1983	2.419	1.001	0.000	3.420	1.075	7.256
1984	0.000	1.031	0.000	1.031	0.255	7.511
1985	0.000	1.062	0.000	1.062	0.228	7.739
1986	2.094	1.328	0.000	3.422	0.698	8.437
1987	0.000	1.368	0.000	1.368	0.222	8.659
1988	0.583	1.455	0.000	2.041	0.301	8.960
1989	2.288	1.758	0.000	4.046	0.539	9.500
1990	0.000	1.811	0.000	1.811	0.193	9.693
1991	0.000	1.865	0.000	1.865	0.173	9.866
1992	2.5[illegible]	2.[illegible]1	0.000	4.701	0.410	10.277
1993	0.000	2.267	0.000	2.267	0.159	10.436
1994	0.000	2.335	0.000	2.335	0.143	10.579

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	11.354	15.430	6.110
LESS RESID. VALUE	11.354	15.893	0.971
NET CAPITAL COSTS	0.000	-0.463	5.139
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	14.864	23.429	4.468
TOTAL COSTS	14.864	22.966	9.607

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TABLE E-65.- MIUS OPTION I CONTROLS SUBSYSTEM (INPUTS TO THE DCF PROGRAM)

YEAR	CAPITAL ($1973 \$ \times 10^{-6}$)	FUEL ($BTU \times 10^{-9}$)	ELECTRICITY ($KWH \times 10^{-6}$)	OTHER O-AND-M INCLUDING LABOR ($1973 \$ \times 10^{-6}$)
1975	1.6760	.00	.000	.1970
1976	.3740	.00	.000	.2275
1977	1.4260	.00	.000	.3825
1978	.0000	.00	.000	.3825
1979	.0000	.00	.000	.3825
1980	1.4260	.00	.000	.5375
1981	.0000	.00	.000	.5375
1982	.0000	.00	.000	.5375
1983	1.8000	.00	.000	.7230
1984	.0000	.00	.000	.7230
1985	.0000	.00	.000	.7230
1986	1.4260	.00	.000	.8780
1987	.0000	.00	.000	.8780
1988	.3740	.00	.000	.9085
1989	1.4260	.00	.000	1.0635
1990	.0000	.00	.000	1.0635
1991	.0000	.00	.000	1.0635
1992	1.4260	.00	.000	1.2185
1993	.0000	.00	.000	1.2185
1994	.0000	.00	.000	1.2185

TABLE E-66.- MIUS OPTION I BUILDING COSTS (DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01758 DOLLARS PER KWH
THIS RUN MADE 11/ 5/73

D. C. F. ANALYSIS FOR
MIUS BUILDINGS, OPTION I - 6/8/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	0.376	0.008	0.000	0.384	0.383	0.383
1976	0.000	0.006	0.000	0.006	0.006	0.389
1977	1.173	0.032	0.000	1.206	0.928	1.297
1978	0.000	0.033	0.000	0.033	0.019	1.316
1979	0.000	0.034	0.000	0.034	0.017	1.333
1980	0.436	0.044	0.000	0.480	0.236	1.569
1981	0.000	0.046	0.000	0.046	0.017	1.586
1982	0.000	0.047	0.000	0.047	0.015	1.602
1983	0.476	0.058	0.000	0.534	0.172	1.774
1984	0.000	0.060	0.000	0.060	0.015	1.789
1985	0.000	0.062	0.000	0.062	0.013	1.802
1986	0.520	0.074	0.000	0.595	0.126	1.928
1987	0.000	0.077	0.000	0.077	0.012	1.940
1988	0.000	0.079	0.000	0.079	0.011	1.951
1989	0.569	0.093	0.000	0.662	0.092	2.043
1990	0.000	0.096	0.000	0.096	0.010	2.053
1991	0.000	0.099	0.000	0.099	0.009	2.063
1992	0.621	0.115	0.000	0.736	0.067	2.130
1993	0.000	0.118	0.000	0.118	0.008	2.138
1994	0.000	0.121	0.000	0.121	0.007	2.145

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	3.168	4.171	1.885
LESS RESID. VALUE	1.775	2.551	0.156
NET CAPITAL COSTS	1.393	1.621	1.729
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.836	1.304	0.260
TOTAL COSTS	2.229	2.925	1.989

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TABLE E-67.- MIUS OPTION I EQUIPMENT BUILDING COSTS

(INPUTS TO DCF PROGRAM)

Year	Description	Capital cost, 1973 $	Total cost, 1973 $	Maintenance cost, 1973 $
1975	Village center Three neighborhoods	145 362 208 983	0.3543×10^6	0.0071×10^6
1976				.0071
1977	Town center Village center Three neighborhoods Central plant	338 809 145 362 208 983 349 240	1.042	.0279
1978				.0279
1979				.0279
1980	Village center Three neighborhoods	145 362 208 983	.3543	.0350
1981				.0350
1982				.0350
1983	Village center Three neighborhoods	145 362 208 983	.3543	.0421
1984				.0421
1985				.0421
1986	Village center Three neighborhoods	145 362 208 983	.3543	.0492
1987				.0492
1988				.0492
1989	Village center Three neighborhoods	145 362 208 983	.3543	.0563
1990				.0563
1991				.0563
1992	Village center Three neighborhoods	145 362 208 983	.3543	.0634
1993				.0634
1994				.0634

TABLE E-68.- MIUS OPTION I TRENCHING COSTS (DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01758 DOLLARS PER KWH
THIS RUN MADE 11/ 5/73

D. C. F. ANALYSIS FOR
MIUS UTILITY TRENCHING, OPTION I - 8/24/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	1.097	0.000	0.000	1.097	1.097	1.097
1976	0.323	0.000	0.000	0.323	0.281	1.378
1977	1.330	0.000	0.000	1.330	1.006	2.384
1978	0.172	0.000	0.000	0.172	0.113	2.497
1979	0.177	0.000	0.000	0.177	0.101	2.598
1980	1.393	0.000	0.000	1.393	0.693	3.291
1981	0.187	0.000	0.000	0.187	0.081	3.372
1982	0.321	0.000	0.000	0.321	0.121	3.493
1983	1.523	0.000	0.000	1.523	0.498	3.990
1984	0.205	0.000	0.000	0.205	0.058	4.049
1985	0.211	0.000	0.000	0.211	0.052	4.101
1986	1.664	0.000	0.000	1.664	0.358	4.458
1987	0.224	0.000	0.000	0.224	0.042	4.500
1988	0.383	0.000	0.000	0.383	0.062	4.562
1989	1.818	0.000	0.000	1.818	0.257	4.819
1990	0.245	0.000	0.000	0.245	0.030	4.849
1991	0.252	0.000	0.000	0.252	0.027	4.876
1992	2.073	0.000	0.000	2.073	0.193	5.069
1993	0.358	0.000	0.000	0.358	0.029	5.098
1994	0.368	0.000	0.000	0.368	0.026	5.124

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	10.298	14.324	5.124
LESS RESID. VALUE	10.298	14.753	0.901
NET CAPITAL COSTS	0.000	-0.430	4.222
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.000	0.000	0.000
TOTAL COSTS	0.000	-0.430	4.222

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TABLE E-69.- MIUS OPTION I UTILITY TRENCHING COSTS (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Village A:		
	Village center		
	Wastewater	89 987	
	Common utility	20 425	
	Neighborhoods A-1, A-2, and A-3 submains		
	Wastewater	568 128	
	Common utility	157 320	
	Neighborhoods A-1, A-2, and A-3 laterals		
	One-third of wastewater	123 452	
	One-third of common utility	74 520	1.034×10^6
1976	Village A:		
	Neighborhoods A-1, A-2, and A-3 laterals		
	One-third of wastewater	123 452	
	One-third of common utility	74 520	
	Town center mains:		
	Wastewater	75 998	
	Common utility	21 642	.2956
1977	Village A:		
	Neighborhoods A-1, A-2, and A-3 laterals		
	One-third of wastewater	123 452	
	One-third of common utility	74 520	
	Village B:		
	Village center (same as village A center)	110 403	
	Neighborhoods B-1, B-2, and B-3 submains (same as neighborhood submains in village A)	725 448	
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	1.182
1978	Village B:		
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	.1485
1979	Village B:		
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	.1485
1980	Village B:		
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	
	Village C:		
	Village center (same as village A center)	110 403	
	Neighborhoods C-1, C-2, and C-3 submains (same as neighborhood submains in village A)	725 448	

TABLE E-69.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals (same as neighborhood laterals in village B)	148 476	1.133×10^6
1981	Village C:		
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals	148 479	.1485
1982	Village C:		
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals	148 479	
	Town center mains		
	Wastewater	75 998	
	Common utility	21 642	.2461
1983	Village C:		
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals	148 479	
	Village D:		
	Village center (same as village A center)	110 403	
	Neighborhoods D-1, D-2, and D-3 submains (same as neighborhood submains in village A)	725 448	
	Neighborhoods D-1, D-2, and D-3 laterals (same as neighborhood laterals in village B)	148 479	1.133
1984	Village D:		
	One-fourth of neighborhoods D-1, D-2, and D-3 laterals	148 479	.1485
1985	Village D:		
	One-fourth of neighborhoods D-1, D-2, and D-3 laterals	148 479	.1485
1986	Village D:		
	One-fourth of neighborhoods D-1, D-2, and D-3 laterals	148 479	
	Village E:		
	Village center (same as village A center)	110 403	
	Neighborhoods E-1, E-2, and E-3 submains (same as neighborhood submains in village A)	725 448	
	Neighborhoods E-1, E-2, and E-3 laterals (same as neighborhood laterals in village B)	148 479	1.133
1987	Village E:		
	One-fourth of neighborhoods E-1, E-2, and E-3 laterals	148 479	.1485

TABLE E-69.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1988	Village E:		
	One-fourth of neighborhoods E-1, E-2, and E-3 laterals	148 479	
	Town center mains		
	Wastewater	75 998	
	Common utility	21 642	0.2461×10^6
1989	Village E:		
	One-fourth of neighborhoods E-1, E-2, and E-3 laterals	148 479	
	Village F:		
	Village center (same as village A center)	110 403	
	Neighborhoods F-1, F-2, and F-3 submains (same as neighborhood submains in village A)	725 448	1.017
	Neighborhoods F-1, F-2, and F-3 laterals (same as neighborhood laterals in village B)	148 479	1.133
1990	Village F:		
	One-fourth of neighborhoods F-1, F-2, and F-3 laterals	148 479	.1485
1991	Village F:		
	One-fourth of neighborhoods F-1, F-2, and F-3 laterals	148 479	.1485
1992	Village F:		
	One-fourth of neighborhoods F-1, F-2, and F-3 laterals	148 479	
	Village G:		
	Village center (same as village A center)	110 403	
	Neighborhoods G-1, G-2, and G-3 submains (same as neighborhood submains in village A)	725 448	
	Neighborhoods G-1, G-2, and G-3 laterals (same as neighborhood laterals in village A)	197 972	1.182
1993	Village G:		
	One-third of neighborhoods G-1, G-2, and G-3 laterals	197 972	.1980
1994	Village G:		
	One-third of neighborhoods G-1, G-2, and G-3 laterals	197 972	.1980

TABLE E-70.- ILLUSTRATION OF MIUS OPTION I WASTEWATER TRENCHING COSTS

[Baseline collection system]

Manhole position		Line length, ft	Pipe diameter in.	Depth, ft		Trench cost, $/ft	Total trench cost, $
From -	To -			Start	End		
Village submains							
29	30	500	15	11.26	12.74	9.75	4 875
30	31	400	15	12.74	13.92	11.20	4 480
31	32	400	15	13.92	15.10	12.85	5 140
39	40	550	15	11.26	12.88	9.75	5 362
High school	32	1500	8	6.0	16.50	8.85	13 275
32	35	450	18	16.50	[1]17.50	17.10	7 695
35	36	450	18	17.50	[1]18.50	18.35	8 258
36	37	200	18	18.50	[1]18.97	18.65	3 730
37	40	550	24	18.97	[2]19.85	19.00	10 450
Total							63 265
Other laterals							
Elementary school	13	900	8	6	12.3	6.55	5 895
Townhouse	11	550	8	6	9.85	5.50	3 025
Townhouse	11	650	8	6	10.55	6.10	3 965
Townhouse	Main	100	8	6	6.7	4.40	2 640
Townhouse	12	100	8	6	6.7	4.40	440
Townhouse	14	100	8	6	6.7	4.40	440
Townhouse	12	200	8	6	7.4	4.60	920
Townhouse	14	200	8	6	7.4	4.60	920
Garden apartment	28	550	8	6	9.85	5.50	3 025
Recreation center	High rise	750	8	6	11.25	6.40	4 800
High rise	36	850	8	11.25	17.20	12.30	10 455
Commercial area	35	100	8	12	12.70	10.20	1 020
Office building	31	100	8	12	12.70	10.20	1 020
Office building	Main	100	8	12	12.70	10.20	1 020
Total							39 585

[1]Includes 5-foot shored trench at bottom.
[2]Includes 5-foot shored trench at bottom and 3-inch wide at trench bottom.

TABLE E-70.- Concluded

Manhole position		Line length, ft	Pipe diameter in.	Depth, ft		Trench cost, $/ft	Total trench cost, $
From -	To -			Start	End		
Baseline village center							
Total submains							63 265
Other laterals							39 585
Total							102 850
MIUS option I additions to other laterals							
Office building	33	400	6	12.00	14.80	10.40	4 160
34	46	700	8	6.0	10.90	6.20	4 340
45	46	500	8	14.35	17.85	15.60	7 800
46	47	450	12	17.85	[1]19.50	18.15	8 168
47	MIUS	550	12	19.50	[1]22.00	23.00	12 650
Total							37 118
MIUS option I subtractions from submains							
29	30						4 875
30	31						4 480
31	32						5 140
39	40						5 362
32	35						7 695
35	36						8 258
36	37						3 730
37	40						10 450
Total							49 990
Village center net, MIUS option I							
Submains							13 275
Other laterals							76 703
Total							89 978

[1]Includes 5-foot shoring at bottom.

TABLE E-71.- MIUS OPTION II VILLAGE COMPLEX

COST SUMMARY

Subsystem	Capital cost, 1973 $
Electrical power:	
Generators and equipment	6 218 200
Distribution	1 938 870
General plant	33 030
Fuel distribution system	58 150
Total	8 248 250
Water supply[1]:	
Potable water supply piping	571 936
Fire water supply piping	651 269
Water pond	22 280
Potable water pumps	8 320
Fire water pumps	12 504
Neighborhood development	257 520
Treatment plant	517 000
Total	2 040 829
Hot water:	
Single-family-dwelling hot-water tanks	421 000
Townhouse hot-water tanks	116 640
Garden apartment hot-water tanks	34 992
Elementary school	3 711
Middle school	1 393
High school	1 393
Village high-rise apartment	8 358
Village office buildings	2 786
Recreation center	1 237
Village shopping center	450
Total	591 960
Wastewater:	
Lift stations	240 000
MIUS lift station	50 000
Wastewater piping	269 229
Manholes	81 200
Neighborhood development	218 300
Treatment plant	2 257 000
Total	3 115 729

[1]Does not include costs of source supply materials and equipment.

TABLE E-71.-Continued

Subsystem	Capital cost, 1973 $
HVAC:	
Single-family-dwelling heat pumps	3 294 060
Townhouse fan coil units	272 160
Garden apartment fan coil units	216 756
Elementary school fan coil units	18 750
Middle school fan coil units	21 186
High school fan coil units	21 186
Village high-rise apartment fan coil units	164 976
Village office buildings fan coil units	87 912
Recreation center fan coil unit	14 853
Village shopping center fan coil unit	29 114
Absorption chillers	328 800
Compression chillers	243 620
Cooling pond	192 000
Chilled-water pumps	81 020
Hot-water pumps (high-grade)	25 540
Waste heat pumps (low-grade)	29 000
Pipe:	
20 in.	495 000
16 in.	36 600
14 in.	24 150
12 in.	915 632
10 in.	729 178
8 in.	422 550
6 in.	161 568
5 in.	162 108
4 in.	52 562
3-1/2 in.	41 360
3 in.	47 863
2-1/2 in.	138 869
2 in.	39 697
1-1/2 in.	61 244
1-1/4 in.	25 110
Total	8 394 424
Solid waste:	
Incinerators	1 020 000
Satellite collection vehicles	30 000
Packer trucks	105 000
Blue collection boxes	13 200
Compactor container, 40 yd^3	7 500

TABLE E-71.- Concluded

Subsystem	Capital cost, 1973 $
Compactor containers, 10 yd^3	48 000
Steel-wheeled compactor	8 000
Tractor crawler	8 000
Front-end loader	35 000
Gravity chute systems	36 400
Total	1 311 100
Controls:	
MIUS controls	708 000
MIUS building:	
Village center complex	358 218
Utility trenching:	
Wastewater	930 619
Common utility	443 568
Total	1 374 187
Total	25 076 479

TABLE E-72.- MIUS OPTION II ELECTRICAL POWER SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FØR
MIUS ELECTRICAL PØWER - ØPTIØN II (12/3/73)

COST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	4.151	0.269	0.406	4.826	4.738	4.738
1976	3.321	0.611	1.001	4.932	4.106	8.845
1977	5.768	1.122	1.897	8.787	6.347	15.191
1978	5.148	1.663	2.879	9.690	5.982	21.173
1979	3.438	1.967	3.450	8.855	4.659	25.832
1980	4.300	2.454	4.441	11.195	5.119	30.950
1981	2.593	2.807	5.203	10.602	4.132	35.082
1982	3.781	3.211	6.104	13.096	4.467	39.549
1983	6.636	3.998	7.830	18.463	5.531	45.080
1984	3.971	4.530	9.047	17.548	4.485	49.565
1985	3.164	4.892	9.946	18.001	3.971	53.537
1986	6.100	5.575	11.542	23.217	4.511	58.047
1987	3.096	6.078	12.846	22.020	3.654	61.701
1988	4.517	6.722	14.492	25.731	3.732	65.434
1989	6.669	7.484	16.421	30.574	3.880	69.314
1990	4.914	8.163	18.251	31.328	3.427	72.741
1991	3.582	8.671	19.733	31.986	3.022	75.763
1992	8.913	9.795	22.744	41.452	3.458	79.221
1993	3.990	10.537	24.995	39.522	2.819	82.040
1994	5.512	11.295	27.269	44.076	2.744	84.783

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	66.452	93.565	31.603
LESS RESID. VALUE	43.749	66.507	4.064
NET CAPITAL CØSTS	22.703	27.057	27.539
CØSTS FØR FUEL	100.328	220.497	35.545
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	63.648	101.842	17.635
TØTAL CØSTS	186.679	349.396	80.720

CUMULATIVE SERVICE DELIVERED = 10.73830

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	6.188	8.713	2.943
LESS RESID. VALUE	4.074	6.193	0.378
NET CAPITAL CØSTS	2.114	2.520	2.565
CØSTS FØR FUEL	9.343	20.534	3.310
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	5.927	9.484	1.642
TØTAL CØSTS	17.384	32.537	7.517

TABLE E-72.- Concluded

(b) Escalation ratio of 15 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.150
THIS RUN MADE 12/ 3/73

D. C. F. ANALYSIS FOR
MIUS ELECTRICAL POWER - OPTION II (12/3/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	4.151	0.269	0.534	4.954	4.849	4.849
1976	3.321	0.611	1.440	5.372	4.438	9.287
1977	5.768	1.122	2.989	9.880	7.065	16.352
1978	5.148	1.663	4.969	11.780	7.177	23.529
1979	3.438	1.967	6.523	11.927	6.186	29.715
1980	4.300	2.454	9.195	15.949	7.174	36.889
1981	2.593	2.807	11.798	17.198	6.611	43.501
1982	3.781	3.211	15.161	22.152	7.427	50.928
1983	6.636	3.998	21.298	31.931	9.360	60.288
1984	3.971	4.530	26.953	35.454	8.911	69.199
1985	3.164	4.892	32.452	40.508	8.809	78.008
1986	6.100	5.575	41.246	52.922	10.063	88.070
1987	3.096	6.078	50.280	59.454	9.738	97.809
1988	4.517	6.722	62.127	73.366	10.464	108.273
1989	6.669	7.484	77.099	91.252	11.337	119.610
1990	4.914	8.163	93.852	106.929	11.506	131.116
1991	3.582	8.671	111.138	123.391	11.516	142.632
1992	8.913	9.795	140.295	159.003	12.956	155.589
1993	3.990	10.537	168.865	183.392	12.928	168.517
1994	5.512	11.295	201.768	218.575	13.406	181.922

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	66.452	93.565	31.603
LESS RESID. VALUE	43.749	66.507	4.064
NET CAPITAL COSTS	22.703	27.057	27.539
COSTS FOR FUEL	100.328	1079.981	132.684
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	63.648	101.842	17.635
TOTAL COSTS	186.679	1208.880	177.859

CUMULATIVE SERVICE DELIVERED = 10.73830

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	6.188	8.713	2.943
LESS RESID. VALUE	4.074	6.193	0.378
NET CAPITAL COSTS	2.114	2.520	2.565
COSTS FOR FUEL	9.343	100.573	12.356
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	5.927	9.484	1.642
TOTAL COSTS	17.384	112.576	16.563

TABLE E-73.- MIUS OPTION II ELECTRICAL POWER SUBSYSTEM

(INPUTS TO DCF PROGRAM)

Year	Capital, 1973 $	Fuel, Btu	Other O&M, 1973 $	Service delivered, kWh
1975	3.913×10^6	344×10^9	0.246×10^6	3.75×10^7
1976	3.039	807	.543	8.81
1977	5.125	1457	.968	15.91
1978	4.441	2106	1.393	22.99
1979	2.879	2404	1.599	26.24
1980	3.496	2947	1.937	32.17
1981	2.047	3288	2.151	35.90
1982	2.898	3674	2.389	40.11
1983	4.938	4488	2.888	49.00
1984	2.869	4939	3.177	53.92
1985	2.219	5171	3.331	56.45
1986	4.154	5715	3.686	62.39
1987	2.047	6058	3.901	66.13
1988	2.899	6509	4.189	71.06
1989	4.156	7024	4.528	76.68
1990	2.973	7435	4.795	81.17
1991	2.104	7656	4.945	83.60
1992	5.082	8404	5.423	91.75
1993	2.209	8796	5.664	96.03
1994	2.963	9139	5.895	99.77

TABLE E-74.- HIUS OPTION II ELECTRICAL POWER SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Village center A powerplant:		
	Four 4415-kW generators	3 090 500	
	One 3500-kVA transformer	18 600	
	General plant	20 550	
	One-third of distribution, village center A	646 900	
	Fuel system (including fuel)	136 438	3.913×10^6
1976	Village center A powerplant:		
	Three 4415-kW generators	2 317 875	
	One 3500-kVA transformer	18 600	
	One-third of distribution, village center A	644 980	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	18 912	3.039
1977	Village center A powerplant:		
	One 4415-kW generator	772 625	
	Village center B powerplant:		
	Three 4415-kW generators	2 317 875	
	One 3400-kVA transformer	18 600	
	General plant	20 550	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	
	General plant	15 160	
	One-third of distribution, village center A	646 990	
	One-fourth of distribution, village center B	483 140	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	18 912	5.125
1978	Village center B powerplant:		
	Three 4415-kW generators	2 317 875	
	One 3500-kVA transformer	18 600	
	Town center powerplant:		
	Two 4415-kW generators	1 545 250	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village center B	483 140	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	17 562	4.441
1979	Village center B powerplant:		
	One 4415-kW generator	772 625	
	Town center powerplant:		
	Two 4415-kW generators	1 545 250	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village center B	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	17 562	2.879
1980	Village center B powerplant:		
	One 4415-kW generator	772 625	
	Village center C powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	General plant	20 550	
	One-fourth of distribution, village center B	484 590	
	One-fourth of distribution, village center C	483 140	
	One-fifteenth of distribution, town center	38 200	
	Fuel system (including fuel)	133 312	3.496
1981	Village center C powerplant:		
	Two 4415-kW generators	1 545 250	
	One-fourth of distribution, village center C	484 590	
	Fuel system	17 562	2.047
1982	Village center C powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village center C	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	17 562	2.898

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TABLE E-74.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1983	Village center C powerplant:		
	Two 4415-kW generators	1 545 250	
	Village center D powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	General plant	20 550	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	One 900-kVA transformer	10 400	
	One-fourth of distribution, village center C	484 590	
	One-fourth of distribution, village center D	483 140	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	18 912	4.938×10^6
1984	Village center D powerplant:		
	Two 4415-kW generators	1 545 250	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	One 900-kVA transformer	10 400	
	One-fourth of distribution, village center D	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system (including fuel)	17 562	2.869
1985	Village center D powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	One-fourth of distribution, village D	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system (including fuel)	131 962	2.219
1986	Village center D powerplant:		
	Two 4415-kW generators	1 545 250	
	Village center E powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	General plant	20 550	
	One-fourth of distribution, village center D	484 590	
	One-fourth of distribution, village center E	483 140	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	18 912	4.154
1987	Village center E powerplant:		
	Two 4415-kW generators	1 545 250	
	One-fourth of distribution, village center E	484 590	
	Fuel system	17 562	2.047
1988	Village center E powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	Two 900-kVA transformers	20 800	
	One-fourth of distribution, village center E	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	18 912	2.899
1989	Village center E powerplant:		
	Two 4415-kW generators	1 545 250	
	Village center F powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	General plant	20 550	
	One-fourth of distribution, village center E	484 590	
	One-fourth of distribution, village center F	483 140	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	20 475	4.156

TABLE E-74.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1990	Village center F powerplant:		
	Two 4415-kW generators	1 545 250	
	Town center powerplant:		
	One 4415-kW generator	772 625	
	One-fourth of distribution, village center F	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system (including fuel)	131 962	2.973x10⁶
1991	Village center F powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	One-fourth of distribution, village center F	484 590	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	17 562	2.104
1992	Village center F powerplant:		
	Two 4415-kW generators	1 545 250	
	Village center G powerplant:		
	Three 4415-kW generators	2 317 875	
	One 900-kVA transformer	10 400	
	General plant	20 550	
	One-fourth of distribution, village center F	484 590	
	One-third of distribution, village center G	646 990	
	One-fifteenth of distribution, town center	38 200	
	Fuel system	18 912	5.083
1993	Village center G powerplant:		
	Two 4415-kW generators	1 545 250	
	One 3500-kVA transformer	18 600	
	One-third of distribution, village center G	644 980	
	Fuel system	0	2.209
1994	Village center G powerplant:		
	Three 4415-kW generators	2 317 875	
	One-third of distribution, village center G	644 980	
	Fuel system	0	2.963

TABLE E-75.- MIUS OPTION II ELECTRICAL POWER DISTRIBUTION

(COMPONENT CAPITAL COSTS)

Component	Cost, $
Village complex[1]	
Cost of one-third village complex:	
102 150 ft of 500-MCM wire at $3.58/ft	365 697
34 050 ft of 1/0 ground wire at $1.26/ft	42 903
132 transformers (88 kVA) at $1450 ea.	191 400
Thirteen 800-kW switchgears at $3460 ea.	44 980
Total	644 980
Subtract one transformer the first year	1 450
	643 530
Add one switchgear the first year	3 460
	646 990
Cost of one-fourth village complex:	
76 612 ft of 500-MCM wire at $3.58/ft	274 271
25 530 ft of 1/0 ground wire at $1.26/ft	32 168
Ninety-nine 88-kVA transformers at $1450 ea.	143 550
Ten 800-kW switchgears at $3460 ea.	34 600
Total	484 589
Subtract one transformer the first year	1 450
	483 139
Cost of town center (1/15 totals):	
3700 ft of 600-MCM wire at $3.85/ft	14 230
1233 ft of 1/0 ground wire at $1.26/ft	1 550
9/15 of 4450-kVA transformer at $20 000 ea.	12 000
Three 800-kW switchgears at $3460 ea.	10 400
Total	38 180
Items listed under general plant	
Each village complex:	
One 30 000-gal fuel tank	7 300
Initial fuel load	4 280
One 5-ton crane	3 970
Tools	5 000
Town center:	
One 10 000-gal fuel tank	4 760
Initial fuel load	1 430
One 5-ton crane	3 970
Tools	5 000

[1]Village center plus three neighborhoods.

TABLE E-76.- MIUS OPTION II FUEL DISTRIBUTION SUBSYSTEM

(ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Central storage tank[1]	33 000	
	Two 15-hp pumps	1 563 ea.	
	Two 2-hp pumps (village A)	675 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	0.0550x10[6]
1976	Two 2-hp pumps (town center)	675 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0189
1977	Two 2-hp pumps (village B)	675 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0189
1978	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1979	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1980	Central storage tank[1]	33 000	
	Two 2-hp pumps (village C)	675 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0519
1981	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1982	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1983	Two 2-hp pumps (village D)	675 ea.	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0189
1984	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0176
1985	Central storage tank[1]	33 000	
	2-1/2-in. main	4 122	
	1-in. secondary	13 440	.0506

[1]Capital costs for the initial fuel loads for each of four tanks were included in the DCF program analyses.

TABLE E-76.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1986	Two 2-hp pumps (village E) 2-1/2-in. main 1-in.-secondary	675 ea. 4 122 13 440	0.0189×10^6
1987	2-1/2-in. main 1-in. secondary	4 122 13 440	.0176
1988	Two 2-hp pumps (town center) 2-1/2-in. main 1-in. secondary	675 ea. 4 122 13 440	.0189
1989	One 15-hp pump Two 2-hp pumps (village F) 2-1/2-in. main 1-in. secondary	1 563 675 ea. 4 122 13 440	.0205
1990	Central storage tank[1] 2-1/2-in. main 1-in. secondary	33 000 4 122 13 440	.0506
1991	2-1/2-in. main 1-in. secondary	4 122 13 440	.0176
1992	Two 2-hp pumps (village G) 2-1/2-in. main 1-in. secondary	675 ea. 4 122 13 440	.0189
1993	(2)		
1994	(2)		

[1]Capital costs for the initial fuel loads for each of four tanks were included in the DCF program analyses.
[2]Fuel distribution system complete.

TABLE E-77.- MIUS OPTION II WATER SUPPLY SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.050
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FØR
MIUS WATER SUPPLY SYSTEM - ØPTIØN II (11/30/73)

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	20.102	0.018	0.000	20.120	20.117	20.117
1976	1.052	0.044	0.000	1.096	0.948	21.065
1977	2.630	0.103	0.000	2.733	2.057	23.122
1978	0.235	0.159	0.000	0.394	0.246	23.368
1979	0.264	0.198	0.000	0.462	0.250	23.617
1980	3.010	0.249	0.000	3.258	1.604	25.221
1981	0.244	0.295	0.000	0.539	0.217	25.437
1982	0.252	0.344	0.000	0.596	0.207	25.645
1983	3.170	0.407	0.000	3.577	1.152	26.797
1984	0.267	0.476	0.000	0.743	0.194	26.990
1985	0.275	0.533	0.000	0.808	0.183	27.173
1986	4.225	0.602	0.000	4.827	1.021	28.193
1987	0.960	0.673	0.000	1.634	0.289	28.482
1988	0.301	0.754	0.000	1.055	0.155	28.638
1989	3.497	0.812	0.000	4.308	0.594	29.232
1990	0.321	0.999	0.000	1.320	0.146	29.378
1991	0.337	1.077	0.000	1.414	0.136	29.514
1992	4.552	1.192	0.000	5.744	0.519	30.033
1993	0.349	1.306	0.000	1.655	0.120	30.153
1994	0.359	1.408	0.000	1.767	0.111	30.265

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	37.508	46.402	28.371
LESS RESID. VALUE	29.208	37.916	2.317
NET CAPITAL CØSTS	8.300	8.487	26.054
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	7.196	11.649	1.894
TØTAL CØSTS	15.497	20.135	27.948

CUMULATIVE SERVICE DELIVERED = 53.48000

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.701	0.868	0.530
LESS RESID. VALUE	0.546	0.709	0.043
NET CAPITAL CØSTS	0.155	0.159	0.487
CØSTS FØR FUEL	0.000	0.000	0.000
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.135	0.218	0.035
TØTAL CØSTS	0.290	0.377	0.523

TABLE E-78.- MIUS OPTION II WATER SUPPLY SUBSYSTEM

(INPUTS TO DCF PROGRAM)

Year	Capital, 1973 $	Useful life, yr	O&M, 1973 $ (1)	Service delivered, gal
1975	13.823×10^6 4.608 .517	100 50 30	0.0161×10^6	0.12×10^9
1976	.334 .112 .517	100 50 30	.0390	.29
1977	1.365 .455 .517	100 50 30	.0888	.66
1978	.152 .051	100 50	.133	.99
1979	.166 .055	100 50	.1613	1.20
1980	1.447 .483 .517	100 50 30	.1963	1.46
1981	.145 .048	100 50	.226	1.68
1982	.145 .048	100 50	.256	1.90
1983	1.381 .461 .517	100 50 30	.294	2.19
1984	.145 .048	100 50	.334	2.48
1985	.145 .048	100 50	.363	2.70
1986	1.770 .590 .517	100 50 30	.398	2.96

[1]Treatment plant O&M labor at 6.64¢/1000 gal; chemicals at 2.69¢/1000 gal; miscellaneous at 2.46¢/1000 gal; distribution system O&M at 1.66¢/1000 gal.

TABLE E-78.- Concluded

Year	Capital, 1973 $	Useful life, yr	O&M, 1973 $ (1)	Service delivered, gal
1987	C.476x10⁶ .159	100 50	0.432x10⁶	3.21x10⁹
1988	.145 .048	100 50	.470	3.49
1989	1.246 .416 .517	100 50 30	.491	3.65
1990	.145 .049	100 50	.587	4.36
1991	.148 .050	100 50	.614	4.56
1992	1.559 .520 .517	100 50 30	.660	4.90
1993	.145 .048	100 50	.702	5.22
1994	.145 .048	100 50	.735	5.46

[1]Treatment plant O&M labor at 6.64¢/1000 gal; chemicals at 2.69¢/1000 gal; miscellaneous at 2.46¢/1000 gal; distribution system O&M at 1.66¢/1000 gal.

TABLE E-79.- MIUS OPTION II WATER SUPPLY SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Village complex A, first-yr development:		
	Village center piping		
	350 ft of 2-in. PVC at $2.16/ft	756	
	800 ft of 3-in. PVC at $3.80/ft	3 040	
	450 ft of 6-in. PVC at $11.34/ft	5 103	
	4600 ft of 8-in. cast iron at $12.86/ft	59 156	
	3950 ft of 12-in. cast iron at $22.31/ft	88 125	
	1000 ft of 16-in. cast iron at $35.80/ft	35 800	
	Village complex fire piping		
	700 ft of 6-in. monoline at $7.80/ft	5 460	
	2900 ft of 8-in. monoline at $11.24/ft	32 596	
	1550 ft of 15-in. monoline at $22.94/ft	35 557	
	Village complex fire pumps		
	Three pumps, 1500 gal/min	12 504	
	Village complex water pond		
	11 140 yd^3 at 50¢/yd^3	5 570	
	Three neighborhood mains		
	3000 ft of 1.5-in. PVC at $1.80/ft	5 400	
	3600 ft of 2-in. PVC at $2.16/ft	7 776	
	4650 ft of 3-in. PVC at $3.80/ft	17 670	
	21 600 ft of 6-in. PVC at $11.34/ft	244 944	
	8100 ft of 8-in. cast iron at $12.86/ft	104 166	
	Neighborhood fire piping		
	17 400 ft of 8-in. monoline at $11.24/ft	195 576	
	24 000 ft of 10-in. monoline at $15.92/ft	382 080	
	Neighborhood water ponds		
	33 420 yd^3 at 50¢/yd^3	16 710	
	Potable water supply pumps		
	Four pumps, 529 gal/min	8 320	
	Neighborhood development (A):		
	One-third of potable water supply piping (22 000 ft of 3-in. PVC)	84 360	
	One-third of fire piping (22 200 ft of 6-in. monoline)	173 160	
	Water source supply pumps:		
	Pump station	28 000	
	Pump, 3140 gal/min	4 578	
	Source supply piping:		
	79 200 ft. of 42-in. cast iron at $170.57/ft	13 509 144	
	9600 ft of 16-in. cast iron at $36.84/ft	353 664	
	7750 ft of 24-in. cast iron at $70.18/ft	543 895	
	9360 ft of 30-in. cast iron at $98.27/ft	919 807	
	2400 ft of 36-in. cast iron at $136.58/ft	327 792	
	7100 ft of 42-in. cast iron at $170.57/ft	1 211 047	18.422×10^6
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1976	Village complex A:		
	One-third of neighborhood development	257 520	
	Town center pumps:		
	Two pumps, 500 gal/min	4 160	

TABLE E-79.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	Town center potable water supply piping:		
	200 ft of 3-in PVC at $3.80/ft	760	
	100 ft of 4-in. PVC at $5.49/ft	549	
	1300 ft of 8-in. cast iron at $12.86/ft	16 718	
	800 ft of 10-in. cast iron at $16.91/ft	13 528	
	2750 ft of 12-in. cast iron at $22.31/ft	61 353	
	3100 ft of 14-in. cast iron at $29.64/ft	91 884	
	Town center fire piping:		
	2300 ft of 12-in. monoline at $22.94/ft	52 762	
	5350 ft of 16-in. monoline at $34.62/ft	185 217	0.684×10^6
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1977	Village complex A:		
	One-third of neighborhood development	257 520	
	Village complex B, first-yr development (same as village complex A, 1975)	1 275 309	
	Neighborhood development (B):		
	One-fourth of potable water supply piping (16 650 ft of 3-in. PVC)	63 270	
	One-fourth of fire water piping (16 650 ft of 6-in. monoline)	129 870	
	Town center pump, 500 gal/min	2 080	
	Town center potable water supply piping:		
	300 ft of 6-in. PVC at $11.34/ft	3 402	
	Town center fire piping:		
	300 ft of 12-in. monoline at $22.94/ft	6 882	
	Source supply piping:		
	2400 ft of 6-in. cast iron at $36.84/ft	88 416	1.827
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1978	Village complex B:		
	One-fourth of neighborhood development	193 140	
	Town center potable water supply piping:		
	800 ft of 8-in. cast iron at $12.86/ft	10 288	
	Town center fire piping:		
	700 ft of 12-in. monoline at $22.94/ft	16 058	.219
1979	Village complex B:		
	One-fourth of neighborhood development	193 140	
	Town center pump, 500 gal/min	2 080	
	Town center potable water supply piping:		
	300 ft of 3-in. PVC at $3.80/ft	1 140	
	100 ft of 4-in. PVC at $5.49/ft	549	
	2100 ft of 6-in. PVC at $11.34/ft	23 814	
	Town center fire piping:		
	1900 ft of 8-in. monoline at $11.24/ft	21 356	
	100 ft of 12-in. monoline at $22.94/ft	2 294	.244
1980	Village complex B:		
	One-fourth of neighborhood development	193 140	
	Village complex C, first-yr development (same as village complex A, 1975)	1 275 309	

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TABLE E-79.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	Neighborhood development (C) (same as neighborhood development (B), 1977)	193 140	
	Town center potable water supply piping:		
	300 ft of 6-in. PVC at $11.34/ft	3 402	
	Town center fire piping:		
	350 ft of 3-in. monoline at $11.24/ft	3 934	
	4100 ft of 6-in. monoline at $34.63/ft	141 983	
	Source supply piping:		
	7200 ft of 16-in. cast iron at $36.84/ft	265 248	2.076×10^6
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1981	Village complex C: One-fourth of neighborhood development	193 140	.193
1982	Village complex C: One-fourth of neighborhood development	193 140	.193
1983	Village complex C: One-fourth of neighborhood development	193 140	
	Village complex D, first-yr development (same as village complex A, 1975)	1 275 309	
	Neighborhood development (D) (same as neighborhood development (B), 1977)	193 140	
	Town center potable water supply piping:		
	100 ft of 4-in. PVC at $5.49/ft	549	
	Town center fire piping:		
	100 ft of 12-in. monoline at $22.94	2 294	
	Source supply pump, 3140 gal/min	4 578	
	Source supply piping:		
	2500 ft of 24-in. cast iron at $70.18/ft	175 450	1.844
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1984	Village complex D: One-fourth of neighborhood development	193 140	.193
1985	Village complex D: One-fourth of neighborhood development	193 140	.193
1986	Village complex D: One-fourth of neighborhood development	193 140	
	Village complex E, first-yr development (same as village complex A, 1975)	1 275 309	
	Neighborhood development (E) (same as neighborhood development (B), 1977)	193 140	
	Source supply piping:		
	14 200 ft of 16-in. cast iron at $36.84/ft	523 128	
	2400 ft of 24-in. cast iron at $73.075/ft	175 380	
	Treatment plant, 1.675×10^6 gal/day	517 000	0.517

TABLE E-79.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1987	Village complex E:		
	One-fourth of neighborhood development	193 140	
	Source supply piping:		
	12 000 ft of 16-in. cast iron at $36.84/ft	442 080	0.635×10^6
1988	Village complex E:		
	One-fourth of neighborhood development	193 140	.193
1989	Village complex E:		
	One-fourth of neighborhood development	193 140	
	Village complex F, first-yr development (same as village complex A, 1975)	1 275 309	
	Neighborhood development (F) (same as neighborhood development (B), 1977)	193 140	1.661
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1990	Village complex F:		
	One-fourth of neighborhood development	193 140	
	Town center potable water supply piping:		
	100 ft of 4-in. PVC at $5.49/ft	549	
	Town center fire piping:		
	100 ft of 12-in. monoline at $22.94/ft	2 294	.196
1991	Village complex F:		
	One-fourth of neighborhood development	193 140	
	Source supply pump, 3140 gal/min	4 578	.198
1992	Village complex F:		
	One-fourth of neighborhood development	193 140	
	Village complex G, first-yr development (same as village complex A, 1975)	1 275 309	
	Neighborhood development (G)	257 520	
	(same as neighborhood development (A), 1975)		
	Source supply piping:		
	9600 ft of 16-in. cast iron at $36.84/ft	353 664	2.079
	Treatment plant, 1.675×10^6 gal/day	517 000	.517
1993	Village complex:		
	One-third of neighborhood development	257 520	.258
1994	Village complex G:		
	One-third of neighborhood development	257 520	.258

TABLE E-80.- MIUS OPTION II WASTEWATER SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

(a) Escalation ratio of 5 percent

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FOR
MIUS WASTE WATER SYSTEM - OPTION II (11/30/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	3.659	0.033	0.001	3.694	3.689	3.689
1976	2.819	0.138	0.005	2.961	2.559	6.248
1977	4.163	0.319	0.011	4.493	3.365	9.613
1978	0.250	0.475	0.017	0.743	0.446	10.059
1979	0.258	0.604	0.022	0.884	0.459	10.518
1980	4.365	0.733	0.027	5.125	2.499	13.017
1981	0.274	0.881	0.033	1.187	0.462	13.478
1982	0.282	1.031	0.040	1.352	0.456	13.934
1983	4.770	1.231	0.048	6.048	1.923	15.857
1984	0.299	1.440	0.057	1.796	0.455	16.312
1985	0.308	1.593	0.065	1.966	0.433	16.745
1986	5.212	1.783	0.074	7.069	1.467	18.212
1987	0.327	2.072	0.087	2.486	0.412	18.624
1988	0.337	2.182	0.094	2.613	0.376	19.000
1989	5.695	2.425	0.106	8.226	1.116	20.116
1990	0.357	2.654	0.119	3.130	0.340	20.456
1991	0.368	2.902	0.132	3.402	0.321	20.778
1992	5.894	3.079	0.143	9.116	0.808	21.586
1993	0.520	3.535	0.167	4.222	0.302	21.888
1994	0.536	3.775	0.183	4.493	0.279	22.167

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	30.021	40.691	16.437
LESS RESID. VALUE	20.520	29.852	1.824
NET CAPITAL COSTS	9.501	10.839	14.613
COSTS FOR FUEL	0.647	1.431	0.225
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	20.447	32.885	5.506
TOTAL COSTS	30.595	45.155	20.343

CUMULATIVE SERVICE DELIVERED = 48.79100

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	0.615	0.834	0.337
LESS RESID. VALUE	0.421	0.612	0.037
NET CAPITAL COSTS	0.195	0.222	0.299
COSTS FOR FUEL	0.013	0.029	0.005
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.419	0.674	0.113
TOTAL COSTS	0.627	0.925	0.417

TABLE E-80.- Concluded

(b) Escalation ratio of 15 percent

FUEL CØST IS 102.00 CENTS PER MBTU, WITH ESCALATIØN RATIØ 0.150
THIS RUN MADE 11/30/73

D. C. F. ANALYSIS FØR
MIUS WASTE WATER SYSTEM - ØPTIØN II (11/30/73)

CØST FLØW TABLE
(ALL CØSTS IN $ X 10E6)

YEAR	INVESTMENT CØST	MAINTENANCE CØST	ØPERATIØNS CØST	TØTAL CØST	PRESENT VALUE	CUMULATIVE P.V.CØST
1975	3.659	0.033	0.001	3.694	3.689	3.689
1976	2.819	0.138	0.007	2.964	2.561	6.250
1977	4.163	0.319	0.017	4.500	3.369	9.619
1978	0.250	0.475	0.029	0.755	0.453	10.072
1979	0.258	0.604	0.041	0.903	0.468	10.540
1980	4.365	0.733	0.056	5.154	2.511	13.052
1981	0.274	0.881	0.075	1.229	0.478	13.529
1982	0.282	1.031	0.098	1.411	0.475	14.004
1983	4.770	1.231	0.131	6.131	1.946	15.951
1984	0.299	1.440	0.171	1.910	0.483	16.434
1985	0.308	1.593	0.211	2.113	0.464	16.898
1986	5.212	1.783	0.264	7.259	1.503	18.401
1987	0.327	2.072	0.342	2.741	0.453	18.854
1988	0.337	2.182	0.403	2.922	0.420	19.274
1989	5.695	2.425	0.499	8.619	1.164	20.438
1990	0.357	2.654	0.610	3.622	0.393	20.831
1991	0.368	2.902	0.745	4.015	0.378	21.209
1992	5.894	3.079	0.883	9.856	0.868	22.077
1993	0.520	3.535	1.131	5.185	0.370	22.447
1994	0.536	3.775	1.352	5.662	0.351	22.798

CØST TØTALS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	30.021	40.691	16.437
LESS RESID. VALUE	20.520	29.852	1.824
NET CAPITAL CØSTS	9.501	10.839	14.613
CØSTS FØR FUEL	0.647	7.068	0.856
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	20.447	32.885	5.506
TØTAL CØSTS	30.595	50.792	20.974
CUMULATIVE SERVICE DELIVERED =		48.79100	

AVERAGE UNIT CØSTS FØR THE 20 YEAR PERIØD FRØM 1975 TØ 1994

	1973 PRICES NØN-DISCØUNTED	ESCALATED PRICES NØN-DISCØUNTED	ESCALATED PRICES DISCØUNTED TØ 1975
CAPITAL EQUIP.	0.615	0.834	0.337
LESS RESID. VALUE	0.421	0.612	0.037
NET CAPITAL CØSTS	0.195	0.222	0.299
CØSTS FØR FUEL	0.013	0.145	0.018
ØTHER ØP. CØSTS	0.000	0.000	0.000
MAINTENANCE CØSTS	0.419	0.674	0.113
TØTAL CØSTS	0.627	1.041	0.430

TABLE E-81.- MIUS OPTION II WASTEWATER SUBSYSTEM

(INPUTS TO DCF PROGRAM)

Year	Capital, 1973 $	Useful life, yr	Fuel, Btu (1)	O&M, 1973 $ (2)	Service delivered, gal
1975	2.257×10^6 1.192	30 75	0.949×10^9	0.0306×10^6	0.073×10^9
1976	2.257 .323	30 75	3.796	.1222	.292
1977	2.257 1.442	30 75	8.528	.275	.656
1978	.216	75	12.350	.398	.950
1979	.216	75	15.210	.491	1.17
1980	2.257 1.292	30 75	17.940	.579	1.38
1981	.216	75	20.930	.675	1.61
1982	.216	75	23.790	.767	1.83
1983	2.257 1.292	30 75	27.560	.889	2.12
1984	.216	75	31.330	1.01	2.41
1985	.216	75	33.670	1.085	2.59
1986	2.257 1.292	30 75	36.530	1.179	2.81
1987	.216	75	41.210	1.33	3.17
1988	.216	75	42.250	1.36	3.25
1989	2.257 1.292	30 75	45.500	1.467	3.50
1990	.216	75	48.360	1.559	3.72
1991	.216	75	51.350	1.655	3.95
1992	2.257 1.104	30 75	52.910	1.705	4.07
1993	.288	75	58.890	1.90	4.53
1994	.288	75	61.230	1.97	4.71

[1]Fuel at 13 Btu/gal.

[2]Treatment plant O&M labor, 18.8¢/1000 gal; chemicals, 13.9¢/1000 gal; miscellaneous, 4.5¢/1000 gal; collection system O&M, 4.7¢/1000 gal.

TABLE E-82.- MIUS OPTION II WASTEWATER SUBSYSTEM (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1966 $	Total capital cost	
			1966 $	1973 $
1975	Village complex A first-yr development			
	Village center submains			
	1500 ft of 8-in. sewer at $7/ft	10 500		
	1850 ft of 15-in. sewer at $10/ft	18 500		
	1100 ft of 18-in. sewer at $10.50/ft	11 550		
	550 ft of 24-in. sewer at $14/ft	7 700		
	Village center laterals			
	1900 ft of 8-in. sewer at $7/ft	13 300		
	Village complex manholes, mains, and submains			
	94 manholes at $800 each	75 200		
	Village center manholes			
	15 manholes at $400 each	6 000		
	Lift stations			
	Six, 8-in. submains	90 000		
	Three, 15-in. submains	150 000		
	MIUS lift stations			
	One station	50 000		
	Three neighborhood submains			
	21 120 ft of 8-in. sewer at $7/ft	147 840		
	3750 ft of 10-in. sewer at $8.75 ft	32 813		
	2100 ft of 15-in. sewer at $10/ft	21 000		
	Option II additive deltas			
	900 ft of 21-in. sewer at $11.50/ft	10 350		
	1000 ft of 24-in. sewer at $14/ft	14 000		
	Option II subtractive deltas			
	2350 ft of 8-in. sewer at $7/ft	-16 450		
	Neighborhood development (A)			
	One-third of laterals	179 900		
	25 700 ft of 8-in. sewer			
	96 manholes, one-third of completion	38 400		
	Town center sewer piping			
	250 ft of 12-in. sewer at $9/ft	2 250		
	3100 ft of 15-in. sewer at $10/ft	31 000	0.925×10^6	1.221×10^6
	Treatment plant, 1.675×10^6 gal/day	1 709 848	1.710	2.257
1976	Village complex A			
	One-third of neighborhood development	218 300		
	Town center piping			
	2500 ft of 18-in. sewer at $10.50/ft	26 250	.244	.323
	Treatment plant, 1.675×10^6 gal/day	1 709 848	1.710	2.257
1977	Village complex A			
	One-third of neighborhood development	218 300		
	Village complex B first-yr development	640 429		
	(same as village complex A 1975)			
	Neighborhood development (B)			
	One-fourth of laterals	134 925		
	19 275 ft of 8-in. sewer			
	72 manholes	28 800		
	Town center piping			
	4100 ft of 8-in. sewer at $7/ft	28 700		
	750 ft of 10-in. sewer at $8.25/ft	6 188		
	800 ft of 12-in. sewer at $9/ft	7 200		
	700 ft of 18-in. sewer at $10.50/ft	7 350	1.072	1.415
	Treatment plant, 1.675×10^6 gal/day			
	One plant	1 709 848	1.710	2.257
1978	Village complex B			
	One-fourth of neighborhood development	163 725	.164	.216
1979	Village complex B			
	One-fourth of neighborhood development	163 725	.164	.217

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TABLE E-82.- Concluded

Year	Description	Major component capital cost, 1966 $	Total capital cost 1966 $	Total capital cost 1973 $
1980	Village complex B			
	One-fourth of neighborhood development	163 725		
	Village complex C first-yr development	640 429		
	(same as village complex A 1975)			
	Neighborhood development (C)	163 725	0.968×10^6	1.278×10^6
	(same as 1977)			
	Treatment plant, 1.675×10^6 gal/day			
	One plant	1 709 848	1.710	2.257
1981	Village complex C			
	One-fourth of neighborhood development	163 725	.164	.216
1982	Village complex C			
	One-fourth of neighborhood development	163 725	.164	.216
1983	Village complex C			
	One-fourth of neighborhood development	163 725		
	Village complex D first-yr development	640 429		
	(same as village complex A 1975)			
	Neighborhood development (D)	163 725	.968	1.278
	(same as 1977)			
	Treatment plant, 1.675×10^6 gal/day			
	One plant	1 709 848	1.710	2.257
1984	Village complex D			
	One-fourth of neighborhood development	163 725	.164	.216
1985	Village complex D			
	One-fourth of neighborhood development	163 725	.164	.216
1986	Village complex D			
	One-fourth of neighborhood development	163 725		
	Village complex E first-yr development	640 429		
	(same as village complex A)			
	Neighborhood development (E)	163 725	.968	1.278
	(same as 1977)			
	Treatment plant, 1.675×10^6 gal/day			
	One plant	1 709 848	1.710	2.257
1987	Village complex E			
	One-fourth of neighborhood development	163 725	.164	.216
1988	Village complex E			
	One-fourth of neighborhood development	163 725	.164	.216
1989	Village complex E			
	One-fourth of neighborhood development	163 725		
	Village complex F first-yr development	640 429		
	(same as village complex A 1975)			
	Neighborhood development (F)	163 725	.968	1.278
	(same as 1975)			
	Treatment plant, 1.675×10^6 gal/day			
	One plant	1 709 848	1.710	2.257
1990	Village complex F			
	One-fourth of neighborhood development	163 725	.164	.216
1991	Village complex F			
	One-fourth of neighborhood development	163 725	.164	.216
1992	Village complex F			
	One-fourth of neighborhood development	163 725		
	Village complex G first-yr development	640 429		
	(same as village complex A 1975)			
	Neighborhood development (G)	218 300	1.022	1.350
	(Same as 1975)			
	Treatment plant, 1.675×10^6 gal/day			
	One plant	1 709 848	1.710	2.257
1993	Village complex G			
	One-third of neighborhood development	218 300	.218	.288
1994	Village complex G			
	One-third of neighborhood development	218 300	.218	.288

TABLE E-83.- MIUS OPTION II WASTEWATER (SUBSYSTEM COMPONENT CAPITAL COSTS)

Component	Quantity, ft	Cost, $
Sewer, 8-in.:		
21 neighborhood mains, 7040 ft ea.	147 840	
Seven village center mains, 1500 ft ea.	10 500	
Seven village center laterals, 1900 ft ea.	13 300	
21 neighborhood laterals, 25 700 ft ea.	539 700	
CBD	4 100	
Subtractive	-16 450	
Total	698 990	4 892 930 (7.00/ft)
Sewer, 10-in.:		
21 neighborhood mains, 1250 ft ea.	26 250	
CBD	750	
Total	27 000	222 750 (8.25/ft)
Sewer, 12-in.:		
CBD	1 050	9 450 (9.00/ft)
Sewer, 15-in.:		
21 neighborhood mains, 700 ft ea.	14 700	
Seven village center mains, 1850 ft ea.	12 950	
CBD	3 100	
Total	30 750	307 500 (10.00/ft)
Sewer, 18-in.:		
Seven village center mains, 1100 ft ea.	7 700	
CBD	3 200	
Total	10 900	114 450 (10.50/ft)
Sewer, 21-in:		
900 ft x 7	6 300	72 450 (11.50/ft)
Sewer, 24-in.:		
Additive, 1000 ft x 7	7 000	
Seven village center mains, 550 ft ea.	3 850	
Total	10 850	151 900 (14.00/ft)
Manholes:		
Same as option I		1 374 800
Lift station for -		
Village mains, 8-in., 42 at $ 15 000 ea.		630 000
Village mains, 15-in., 21 at $ 50 000 ea.		1 050 000
MIUS lift stations, 7 at $50 000 ea.		350 000
Total, 1966 $		9 176 230
Total, 1973 $		12 112 623
Plant capital, 1973 $ (2 257 000 x 8)		18 056 000

TABLE E-84.- MIUS OPTION II WASTEWATER SUBSYSTEM

EQUIPMENT COST SUMMARY

Description	Quantity	Unit cost, 1966 $	Total cost, 1966 $
Sewer:			
8 in.	698 990 ft	7.00	4 892 930
10 in.	27 000 ft	8.25	222 750
12 in.	1 050 ft	9.00	9 450
15 in.	30 750 ft	10.00	307 500
18 in.	10 900 ft	10.50	114 450
21 in.	6 300 ft	11.50	72 450
24 in.	10 850 ft	14.00	151 900
Manholes along mains	658	800.00	526 400
Other manholes	2 121	400.00	848 400
Lift stations, 8-in. mains	42	15 000.00	630 000
Lift stations, 15-in. mains	21	50 000.00	1 050 000
MIUS lift stations	7	50 000.00	350 000
Total capital, 1966 $			9 176 000+
Total capital, 1973 $			12 112 000+
Treatment plants, 8 ea. at $2 257 000 (1973 $)			18 056 000
Total capital cost, 1973 $			30 168 000

TABLE E-85.- MIUS OPTION II HVAC SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01745 DOLLARS PER KWH
THIS RUN MADE 9/ 5/73

D. C. F. ANALYSIS FOR
MIUS HVAC - OPTION II 8/10/73 (8/15/73)

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	3.162	0.140	0.000	3.302	3.284	3.284
1976	5.644	0.306	0.000	5.949	5.139	8.422
1977	5.836	0.577	0.000	6.413	4.792	13.214
1978	3.369	0.717	0.000	4.087	2.625	15.840
1979	3.263	0.893	0.000	4.157	2.310	18.150
1980	5.193	1.166	0.000	6.359	3.086	21.236
1981	3.672	1.335	0.000	5.007	2.089	23.325
1982	2.449	1.504	0.000	3.953	1.412	24.737
1983	9.321	1.839	0.000	11.160	3.570	28.307
1984	4.740	2.077	0.000	6.818	1.861	30.168
1985	2.571	2.278	0.000	4.848	1.125	31.293
1986	6.257	2.642	0.000	8.899	1.839	33.132
1987	4.468	2.882	0.000	7.350	1.304	34.435
1988	6.230	3.139	0.000	9.368	1.456	35.891
1989	7.989	3.595	0.000	11.584	1.571	37.462
1990	4.410	3.878	0.000	8.289	0.956	38.419
1991	3.205	4.165	0.000	7.370	0.730	39.148
1992	8.994	4.699	0.000	13.692	1.215	40.364
1993	4.478	5.076	0.000	9.554	0.719	41.082
1994	5.389	5.475	0.000	10.864	0.713	41.795

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	71.379	100.640	33.466
LESS RESID. VALUE	71.378	103.658	6.334
NET CAPITAL COSTS	0.001	-3.018	27.132
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	30.192	48.383	8.330
TOTAL COSTS	30.193	45.365	35.462

CUMULATIVE SERVICE DELIVERED = 1.31659

AVERAGE UNIT COSTS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	54.215	76.440	25.419
LESS RESID. VALUE	54.214	78.732	4.811
NET CAPITAL COSTS	0.001	-2.292	20.608
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	22.932	36.749	6.327
TOTAL COSTS	22.932	34.456	26.935

TABLE E-86.- MIUS OPTION II HVAC SUBSYSTEM COSTS (INPUTS TO DCF PROGRAM)

YEAR	CAPITAL (1973 F X 10^{-6})	FUEL (BTU X 10^{-9})	ELECTRICITY (KWH X 10^{-6})	OTHER O-AND-M INCLUDING LABOR (1973 $ X 10^{-6})	MAN YEARS (O-AND-M)	A/C CAPACITY (TONS)
1975	2.9903	.00	.000	.1282	.00	5961.
1976	5.1647	.00	.000	.2715	.00	15534.
1977	5.1952	.00	.000	.4976	.00	25609.
1978	2.9063	.00	.000	.6008	.00	31273.
1979	2.7330	.00	.000	.7263	.00	34603.
1980	4.2225	.00	.000	.9201	.00	42716.
1981	2.8090	.00	.000	1.0228	.00	48380.
1982	1.8772	.00	.000	1.1190	.00	51710.
1983	6.9357	.00	.000	1.3287	.00	64896.
1984	3.4244	.00	.000	1.4571	.00	70026.
1985	1.8031	.00	.000	1.5509	.00	73356.
1986	4.2604	.00	.000	1.7467	.00	81469.
1987	2.9539	.00	.000	1.8499	.00	87222.
1988	3.9985	.00	.000	1.9559	.00	94646.
1989	4.9785	.00	.000	2.1752	.00	102759.
1990	2.6693	.00	.000	2.2782	.00	107889.
1991	1.8827	.00	.000	2.3752	.00	111219.
1992	5.1290	.00	.000	2.6015	.00	121232.
1993	2.4794	.00	.000	2.7287	.00	125821.
1994	2.8967	.00	.000	2.8576	.00	131488.

TABLE E-87.- MIUS OPTION II HVAC SUBSYSTEM COSTS (CAPITAL AND O&M OUTLAYS)

(a) Input data array

	BUILDING	ELECTRICAL RATE $/KWH	FUEL RATE $/MBTU	LABOR RATE $/MAN-YEAR
1	SINGLE FAMILY	.0000	.0000	10100.0
2	TOWN HOUSE	.0000	.0000	10100.0
3	GARDEN APARTMENT	.0000	.0000	10100.0
4	ELEMENTRY SCHOOL	.0000	.0000	10100.0
5	VILL HI RISE APT	.0000	.0000	10100.0
6	MIDDLE SCHOOL	.0000	.0000	10100.0
7	HIGH SCHOOL	.0000	.0000	10100.0
8	VILL OFFICE BLDG	.0000	.0000	10100.0
9	RECREATION CENTR	.0000	.0000	10100.0
10	SHOPPING CENTER	.0000	.0000	10100.0
11	COLLEGE	.0000	.0000	10100.0
12	SHOPPING MALL	.0000	.0000	10100.0
13	OFFICE BUILDING	.0000	.0000	10100.0
14	HI RISE INN	.0000	.0000	10100.0
15	LO RISE INN	.0000	.0000	10100.0
16	HOSPITAL	.0000	.0000	10100.0
17	HI RISE APARTMNT	.0000	.0000	10100.0
93	TOWN CENTER MIUS	.0000	.0000	10100.0
94	VILL/NBRHD MIUS	.0000	.0000	10100.0

	BUILDING	A/C CAPACITY TONS	A/C POWER KW	ANNUAL HEAT-MBTU	ELECTRICITY KWH X .0001	PERSONNEL MEN	CAPITAL $ X.001	MAINTAINENCE $ X.01
1	SINGLE FAMILY	3.00	.00	.00	.0000	.00	1.590	1.5400
2	TOWN HOUSE	.00	.00	.00	.0000	.00	.280	.0840
3	GARDEN APARTMENT	.00	.00	.00	.0000	.00	.223	.0670
4	ELEMENTRY SCHOOL	.00	.00	.00	.0000	.00	6.250	2.0600
5	VILL HI RISE APT	.00	.00	.00	.0000	.00	27.496	9.6200
6	MIDDLE SCHOOL	.00	.00	.00	.0000	.00	21.186	6.3500
7	HIGH SCHOOL	.00	.00	.00	.0000	.00	21.186	6.3500
8	VILL OFFICE BLDG	.00	.00	.00	.0000	.00	43.956	15.3800
9	RECREATION CENTR	.00	.00	.00	.0000	.00	14.853	5.1900
10	SHOPPING CENTER	.00	.00	.00	.0000	.00	29.114	8.7300
11	COLLEGE	.00	.00	.00	.0000	.00	13.776	6.4400
12	SHOPPING MALL	.00	.00	.00	.0000	.00	800.000	270.0000
13	OFFICE BUILDING	.00	.00	.00	.0000	.00	43.956	15.3800
14	HI RISE INN	.00	.00	.00	.0000	.00	36.200	12.9000
15	LO RISE INN	.00	.00	.00	.0000	.00	19.700	10.0000
16	HOSPITAL	.00	.00	.00	.0000	.00	23.000	6.9000
17	HI RISE APARTMNT	.00	.00	.00	.0000	.00	49.450	23.4900
93	TOWN CENTER MIUS	17800.00	.00	.00	.0000	.00	9414.021	495.5700
94	VILL/NBRHD MIUS	9800.00	.00	.00	.0000	.00	4251.471	292.7700

TABLE E-87.- Continued

(b) Input schedule array

1	713.00	713.00	1247.00	534.00	534.00	1071.00	534.00	534.00
	1071.00	534.00	534.00	1071.00	534.00	534.00	1071.00	534.00
	534.00	1247.00	713.00	713.00				
2	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
3	324.00	324.00	567.00	243.00	243.00	486.00	243.00	243.00
	486.00	243.00	243.00	486.00	243.00	243.00	486.00	243.00
	243.00	567.00	324.00	324.00				
4	1.00	1.00	2.00	.00	1.00	2.00	.00	1.00
	2.00	.00	1.00	2.00	.00	1.00	2.00	.00
	1.00	2.00	1.00	1.00				
5	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.00	4.00	2.00	2.00				
6	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
7	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
8	.00	1.00	1.00	.00	1.00	1.00	.00	1.00
	1.00	.00	.00	1.00	1.00	.00	1.00	1.00
	1.00	1.00	1.00	1.00				
9	.00	1.00	.00	1.00	.00	1.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	1.00	.00
	.00	1.00	.00	.00				
10	.00	.00	1.00	.00	1.00	.00	1.00	.00
	.00	1.00	.00	.00	1.00	.00	.00	1.00
	.00	.00	1.00	.00				
11	.00	.00	.00	1.00	.00	.00	.00	.00
	.00	.00	1.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
12	.00	.00	.00	.00	1.00	.00	.00	.00
	.00	1.00	.00	.00	.00	.00	1.00	.00
	.00	.00	.00	.00				
13	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	1.00	.00	1.00	.00	1.00	.00	1.00
	.00	.00	.00	.00				
14	.00	.00	1.00	.00	.00	.00	1.00	.00
	1.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
15	.00	1.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00				
16	.00	.00	.00	.00	.00	.50	.00	.00
	.00	.00	.00	.00	.00	.00	.50	.00
	.00	.00	.00	.00				
17	.00	.00	.00	.00	1.00	.00	.00	.00
	1.00	.00	.00	1.00	.00	.00	.00	.00
	1.00	.00	.00	.00				
93	.00	.28	.02	.03	.02	.00	.03	.02
	.29	.00	.02	.00	.04	.25	.00	.00
	.02	.00	.00	.00				
94	.19	.25	.41	.36	.14	.50	.36	.19
	.50	.36	.14	.50	.36	.14	.50	.36
	.14	.64	.25	.36				

TABLE E-87.- Continued

(c) Total annual capital expenditures ($\$ \times 10^{-6}$)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	1.0980	1.0980	1.9204	.8224	.8224	1.6493	.8224	.8224	1.6493	.8224
2	TOWN HOUSE	.0907	.0907	.1588	.0680	.0680	.1361	.0680	.0680	.1361	.0680
3	GARDEN APARTMENT	.0723	.0723	.1264	.0542	.0542	.1084	.0542	.0542	.1084	.0542
4	ELEMENTRY SCHOOL	.0062	.0062	.0125	.0000	.0062	.0125	.0000	.0062	.0125	.0000
5	VILL HI RISE APT	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.0550
6	MIDDLE SCHOOL	.0000	.0212	.0000	.0212	.0000	.0212	.0000	.0000	.0212	.0000
7	HIGH SCHOOL	.0000	.0000	.0212	.0000	.0212	.0000	.0212	.0000	.0000	.0212
8	VILL OFFICE BLDG	.0000	.0440	.0440	.0000	.0440	.0440	.0000	.0440	.0440	.0000
9	RECREATION CENTR	.0000	.0149	.0000	.0149	.0000	.0149	.0000	.0000	.0149	.0000
10	SHOPPING CENTER	.0000	.0000	.0291	.0000	.0291	.0000	.0291	.0000	.0000	.0291
11	COLLEGE	.0000	.0000	.0000	.0138	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.8000
13	OFFICE BUILDING	.0000	.0440	.0000	.0440	.0000	.0440	.0000	.0440	.0000	.0440
14	HI RISE THM	.0000	.0000	.0362	.0000	.0000	.0000	.0367	.0000	.0362	.0000
15	LO RISE THM	.0000	.0197	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0115	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0494	.0000	.0000	.0000	.0494	.0000
93	TOWN CENTER MIUS	.0000	2.6359	.1883	.2824	.1883	.0000	.2824	.1883	2.6830	.0000
94	VILL/NBRHD MIUS	1.6581	1.0629	2.5934	1.5305	.5952	2.1257	1.5305	.5952	2.1257	1.5305
	TOTAL	2.9803	5.1647	5.1852	2.9063	2.7330	4.2275	2.8990	1.8772	6.9357	3.4244

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.8224	1.6493	.8224	.8224	1.6493	.8224	.8224	1.9204	1.0980	1.0980	23.0538
2	TOWN HOUSE	.0680	.1361	.0680	.0680	.1361	.0680	.0680	.1588	.0907	.0907	1.9051
3	GARDEN APARTMENT	.0542	.1084	.0542	.0542	.1084	.0542	.0542	.1264	.0723	.0723	1.5173
4	ELEMENTRY SCHOOL	.0062	.0125	.0000	.0062	.0125	.0000	.0062	.0125	.0062	.0062	.1312
5	VILL HI RISE APT	.0550	.0550	.0550	.0550	.0550	.0550	.0550	.1100	.0550	.0550	1.1598
6	MIDDLE SCHOOL	.0000	.0212	.0000	.0000	.0212	.0000	.0000	.0212	.0000	.0000	.1493
7	HIGH SCHOOL	.0000	.0000	.0212	.0000	.0000	.0212	.0000	.0000	.0212	.0000	.1483
8	VILL OFFICE BLDG	.0000	.0440	.0440	.0000	.0440	.0440	.0440	.0440	.0440	.0440	.6154
9	RECREATION CENTR	.0000	.0149	.0000	.0000	.0149	.0000	.0000	.0149	.0000	.0000	.1040
10	SHOPPING CENTER	.0000	.0000	.0291	.0000	.0000	.0291	.0000	.0000	.0291	.0000	.2038
11	COLLEGE	.0138	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0276
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	2.4000
13	OFFICE BUILDING	.0000	.0440	.0000	.0440	.0000	.0440	.0000	.0000	.0000	.0000	.3516
14	HI RISE THM	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.1086
15	LO RISE THM	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0197
16	HOSPITAL	.0000	.0000	.0000	.0000	.0115	.0000	.0000	.0000	.0000	.0000	.0230
17	HI RISE APARTMNT	.0000	.0494	.0000	.0000	.0000	.0000	.0494	.0000	.0000	.0000	.1978
93	TOWN CENTER MIUS	.1883	.0000	.3295	2.3535	.0000	.0000	.1883	.0000	.0000	.0000	9.5082
94	VILL/NBRHD MIUS	.5952	2.1257	1.5305	.5952	2.1257	1.5305	.5952	2.7209	1.0629	1.5305	29.7603
	TOTAL	1.8031	4.2604	2.9539	3.9985	4.9785	2.6683	1.8827	5.1270	2.4794	2.8967	71.3788

TABLE E-87.- Continued

(d) Total annual power consumed (kWh)

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	VILL HI RISE APT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	MIDDLE SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	HIGH SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	VILL OFFICE BLDG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	RECREATION CENTR	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	SHOPPING CENTER	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	COLLEGE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	OFFICE BUILDING	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
93	TOWN CENTER MIUS	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
94	VILL/NBRHD MIUS	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	TOTAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	VILL HI RISE APT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	MIDDLE SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	HIGH SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	VILL OFFICE BLDG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	RECREATION CENTR	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	SHOPPING CENTER	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	COLLEGE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	OFFICE BUILDING	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
93	TOWN CENTER MIUS	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
94	VILL/NBRHD MIUS	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	TOTAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

TABLE E-87.- Continued

(e) Total annual O&M costs ($ x 10^{-6})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.1098	.2196	.4116	.4939	.5761	.7410	.8233	.9055	1.0705	1.1527
2	TOWN HOUSE	.0027	.0054	.0102	.0122	.0143	.0184	.0204	.0225	.0765	.0286
3	GARDEN APARTMENT	.0022	.0043	.0081	.0098	.0114	.0147	.0163	.0179	.0212	.0228
4	ELEMENTARY SCHOOL	.0002	.0004	.0008	.0008	.0010	.0014	.0014	.0016	.0021	.0021
5	VILL HI RISE APT	.0019	.0038	.0058	.0077	.0096	.0115	.0135	.0154	.0173	.0192
6	MIDDLE SCHOOL	.0000	.0006	.0006	.0013	.0013	.0019	.0019	.0019	.0025	.0025
7	HIGH SCHOOL	.0000	.0000	.0006	.0006	.0013	.0013	.0019	.0019	.0019	.0025
8	VILL OFFICE BLDG	.0000	.0015	.0031	.0031	.0046	.0062	.0062	.0077	.0092	.0092
9	RECREATION CENTR	.0000	.0005	.0005	.0010	.0010	.0016	.0016	.0016	.0021	.0021
10	SHOPPING CENTER	.0000	.0000	.0009	.0009	.0017	.0017	.0026	.0026	.0026	.0035
11	COLLEGE	.0000	.0000	.0000	.0006	.0006	.0006	.0006	.0006	.0006	.0006
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0270	.0270	.0270	.0270	.0270	.0540
13	OFFICE BUILDING	.0000	.0015	.0015	.0031	.0031	.0046	.0046	.0062	.0062	.0077
14	HI RISE INN	.0000	.0000	.0013	.0013	.0013	.0013	.0026	.0026	.0039	.0039
15	LO RISE INN	.0000	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0003	.0003	.0003	.0003	.0003
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0023	.0073	.0023	.0023	.0047	.0047
93	TOWN CENTER MIUS	.0000	.0139	.0149	.0164	.0173	.0173	.0188	.0198	.0339	.0339
94	VILL/NBRHD MIUS	.0114	.0197	.0366	.0471	.0512	.0659	.0764	.0805	.0952	.1057
	TOTAL	.1292	.2715	.4976	.6008	.7263	.9201	1.0228	1.1190	1.3287	1.4571

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	1.2349	1.3909	1.4821	1.5643	1.7293	1.8115	1.8937	2.0858	2.1956	2.3059	24.2165
2	TOWN HOUSE	.0306	.0347	.0367	.0348	.0929	.0449	.0469	.0517	.0549	.0572	.6001
3	GARDEN APARTMENT	.0244	.0277	.0293	.0309	.0342	.0358	.0374	.0412	.0434	.0456	.4787
4	ELEMENTARY SCHOOL	.0023	.0027	.0027	.0029	.0033	.0033	.0035	.0039	.0041	.0043	.0449
5	VILL HI RISE APT	.0212	.0231	.0250	.0269	.0289	.0309	.0327	.0366	.0385	.0404	.4098
6	MIDDLE SCHOOL	.0025	.0032	.0032	.0032	.0038	.0038	.0038	.0044	.0044	.0044	.0514
7	HIGH SCHOOL	.0025	.0025	.0032	.0032	.0032	.0038	.0038	.0038	.0044	.0044	.0470
8	VILL OFFICE BLDG	.0092	.0108	.0123	.0123	.0138	.0154	.0169	.0185	.0200	.0215	.2015
9	RECREATION CENTR	.0021	.0026	.0026	.0026	.0031	.0031	.0031	.0036	.0036	.0036	.0420
10	SHOPPING CENTER	.0035	.0035	.0044	.0044	.0044	.0052	.0052	.0052	.0061	.0061	.0646
11	COLLEGE	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0013	.0174
12	SHOPPING MALL	.0540	.0540	.0540	.0540	.0810	.0810	.0810	.0810	.0810	.0810	.8910
13	OFFICE BUILDING	.0077	.0092	.0092	.0109	.0108	.0123	.0123	.0123	.0123	.0123	.1476
14	HI RISE INN	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0568
15	LO RISE INN	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0190
16	HOSPITAL	.0003	.0003	.0003	.0003	.0007	.0007	.0007	.0007	.0007	.0007	.0072
17	HI RISE APARTMNT	.0047	.0070	.0070	.0070	.0070	.0070	.0094	.0094	.0094	.0094	.0963
93	TOWN CENTER MIUS	.0349	.0349	.0367	.0491	.0491	.0491	.0501	.0501	.0501	.0501	.6403
94	VILL/NBRHD MIUS	.1098	.1244	.1350	.1391	.1537	.1692	.1683	.1871	.1944	.2049	2.1697
	TOTAL	1.5509	1.7467	1.8499	1.9559	2.1752	2.2782	2.3752	2.6015	2.7287	2.8576	30.1919

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE E-87.- Concluded

(f) On-line tons of air-conditioning (ton x 10^{-4})

	BUILDING TYPE	YEAR 1	2	3	4	5	6	7	8	9	10
1	SINGLE FAMILY	.2139	.4270	.8019	.9621	1.1223	1.4436	1.6038	1.7640	2.0853	2.2455
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	VILL HI RISE APT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	MIDDLE SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	HIGH SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	VILL OFFICE BLDG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	RECREATION CENTR	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	SHOPPING CENTER	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	COLLEGE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	OFFICE BUILDING	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
93	TOWN CENTER MIUS	.0000	.4989	.5340	.5874	.6230	.6230	.6764	.7120	1.2193	1.2193
94	VILL/NBRHD MIUS	.3822	.6272	1.2250	1.5778	1.7150	2.2050	2.5578	2.6950	3.1850	3.5378
	TOTAL	.5961	1.5534	2.5609	3.1273	3.4603	4.2716	4.8380	5.1710	6.4896	7.0026

	BUILDING TYPE	YEAR 11	12	13	14	15	16	17	18	19	20	TOTAL
1	SINGLE FAMILY	2.4057	2.7270	2.8872	3.0474	3.3687	3.5289	3.6891	4.0632	4.2771	4.4910	47.1555
2	TOWN HOUSE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	GARDEN APARTMENT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	ELEMENTRY SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	VILL HI RISE APT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	MIDDLE SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	HIGH SCHOOL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	VILL OFFICE BLDG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	RECREATION CENTR	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	SHOPPING CENTER	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	COLLEGE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	SHOPPING MALL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	OFFICE BUILDING	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	HI RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	LO RISE INN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	HOSPITAL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	HI RISE APARTMNT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
93	TOWN CENTER MIUS	1.2549	1.2549	1.3172	1.7622	1.7622	1.7622	1.7978	1.7978	1.7978	1.7978	22.9976
94	VILL/NBRHD MIUS	3.6750	4.1650	4.5178	4.6550	5.1450	5.4978	5.6350	6.2622	6.5072	6.8600	72.6278
	TOTAL	7.3356	8.1469	8.7222	9.4646	10.2759	10.7889	11.1219	12.1232	12.5821	13.1488	142.7809

TABLE E-88.- HVAC SUBSYSTEM EQUIPMENT LIST FOR VILLAGE/NEIGHBORHOOD COMPLEX MIUS

Item description	Quantity	Capital, 1973 $		Maintenance, 1973 $		Operation		Utilization
		Cost/unit	Total cost	Cost/unit	Total cost	Operating load, kW	Annual consumption, kWh	
1377-ton absorption chiller	4	82 200	328 800	2702	10 808	39		Option II only
1073-ton compression chiller	4	60 905	243 620	2009	8 036	3228	1 985 200	
Cooling pond, 360 by 162 by 4 ft,	1	192 000			5 760			
Chiller pumps, 1750 gal/min	8	5 455	43 640		1 527	746		
Chiller pumps, 1146 gal/min	8	4 422.5	35 380		1 238	597		
Hot-water pumps, 1339 gal/min	6	4 256	25 540		893	447		
Waste heat pumps, 604 ft head	5	5 800	29 000		1 015	820		
Insulated pipe:								
12 in.	14 240 ft	64.30	915 632					
10 in.	16 040 ft	45.46	739 178					
8 in.	15 000 ft	28.17	422 550					
6 in.	8 800 ft	18.36	161 568					
5 in.	10 800 ft	15.01	162 108					
4 in.	4 840 ft	10.86	52 562					
3-1/2 in.	4 400 ft	9.40	41 360					
3 in.	5 800 ft	8.14	47 863					
2-1/2 in.	20 820 ft	6.67	138 869					
2 in.	6 880 ft	5.77	39 697					
1-1/2 in.	12 200 ft	5.02	61 244					
14 in.	300 ft	80.50	24 150					
16 in.	300 ft	122.00	36 600					
20 in.	3 000 ft	165.00	495 000					
1-1/4 in.	5 400 ft	4.65	25 110					
Total			4 251 471					

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TABLE E-89.- MIUS OPTION II CONTROLS SUBSYSTEM COSTS

(DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01745 DOLLARS PER KWH
THIS RUN MADE 11/ 5/73

D. C. F. ANALYSIS FOR
MIUS CONTROLS SYSTEM, OPTION II - 8/8/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	1.016	0.106	0.000	1.122	1.108	1.108
1976	0.409	0.143	0.000	0.552	0.464	1.572
1977	0.797	0.211	0.000	1.008	0.741	2.313
1978	0.000	0.217	0.000	0.217	0.124	2.437
1979	0.000	0.224	0.000	0.224	0.111	2.548
1980	0.871	0.300	0.000	1.170	0.562	3.111
1981	0.000	0.309	0.000	0.309	0.116	3.227
1982	0.000	0.318	0.000	0.318	0.104	3.331
1983	1.454	0.445	0.000	1.900	0.602	3.933
1984	0.000	0.459	0.000	0.459	0.113	4.046
1985	0.000	0.473	0.000	0.473	0.102	4.148
1986	1.040	0.569	0.000	1.609	0.330	4.478
1987	0.000	0.587	0.000	0.587	0.095	4.573
1988	0.583	0.653	0.000	1.236	0.187	4.760
1989	1.136	0.763	0.000	1.899	0.254	5.015
1990	0.000	0.786	0.000	0.786	0.084	5.099
1991	0.000	0.810	0.000	0.810	0.075	5.174
1992	1.241	0.933	0.000	2.174	0.191	5.364
1993	0.000	0.961	0.000	0.961	0.068	5.432
1994	0.000	0.989	0.000	0.989	0.060	5.492

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	6.328	8.547	3.477
LESS RESID. VALUE	6.328	8.803	0.538
NET CAPITAL COSTS	0.000	-0.256	2.939
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	6.539	10.255	2.016
TOTAL COSTS	6.539	9.998	4.955

TABLE E-90.- MIUS OPTION II CONTROL SUBSYSTEM (INPUT TO DCF PROGRAM)

YEAR	CAPITAL $(1973\ \$ \times 10^{-6})$	FUEL $(BTU \times 10^{-9})$	ELECTRICITY $(KWH \times 10^{-6})$	OTHER O-AND-M INCLUDING LABOR $(1973\ \$ \times 10^{-6})$
1975	.9580	.00	.000	.0967
1976	.3740	.00	.000	.1272
1977	.7080	.00	.000	.1819
1978	.0000	.00	.000	.1819
1979	.0000	.00	.000	.1819
1980	.7080	.00	.000	.1819
1981	.0000	.00	.000	.2366
1982	.0000	.00	.000	.2366
1983	1.0820	.00	.000	.2366
1984	.0000	.00	.000	.3218
1985	.0000	.00	.000	.3218
1986	.7080	.00	.000	.3218
1987	.0000	.00	.000	.3765
1988	.3740	.00	.000	.3765
1989	.7080	.00	.000	.4070
1990	.0000	.00	.000	.4617
1991	.0000	.00	.000	.4617
1992	.7080	.00	.000	.4617
1993	.0000	.00	.000	.5164
1994	.0000	.00	.000	.5164

TABLE E-91.- MIUS OPTION II BUILDING COSTS (DCF PROGRAM OUTPUT)

FUEL COST IS 182.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01745 DOLLARS PER KWH
THIS RUN MADE 11/ 5/73

D. C. F. ANALYSIS FOR
MIUS BUILDINGS, OPTION II - 8/8/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	0.380	0.008	0.000	0.388	0.387	0.387
1976	0.000	0.008	0.000	0.008	0.006	0.393
1977	0.838	0.026	0.000	0.864	0.650	1.043
1978	0.000	0.026	0.000	0.026	0.015	1.059
1979	0.000	0.027	0.000	0.027	0.014	1.072
1980	0.441	0.037	0.000	0.478	0.235	1.307
1981	0.000	0.038	0.000	0.038	0.014	1.321
1982	0.000	0.039	0.000	0.039	0.013	1.334
1983	0.481	0.050	0.000	0.532	0.172	1.506
1984	0.000	0.052	0.000	0.052	0.013	1.519
1985	0.000	0.053	0.000	0.053	0.011	1.530
1986	0.526	0.066	0.000	0.592	0.125	1.656
1987	0.000	0.068	0.000	0.068	0.011	1.667
1988	0.000	0.070	0.000	0.070	0.010	1.677
1989	0.575	0.084	0.000	0.659	0.092	1.768
1990	0.000	0.086	0.000	0.086	0.009	1.777
1991	0.000	0.089	0.000	0.089	0.008	1.786
1992	0.628	0.105	0.000	0.733	0.067	1.852
1993	0.000	0.108	0.000	0.108	0.008	1.860
1994	0.000	0.111	0.000	0.111	0.007	1.867

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	2.894	3.869	1.643
LESS RESID. VALUE	1.671	2.435	0.149
NET CAPITAL COSTS	1.223	1.434	1.494
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.734	1.151	0.224
TOTAL COSTS	1.957	2.585	1.718

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TABLE E-92.- MIUS OPTION II BUILDING COSTS (INPUTS TO THE DCF PROGRAM)

Year	Description	Capital cost, 1973 $	Total cost, 1973 $	Maintenance cost, 1973 $
1975	Village center complex	358 218	0.3582x10⁶	0.0072x10⁶
1976				.0072
1977	Town center Village center complex	386 332 358 218	.7446	.0221
1978				.0221
1979				.0221
1980	Village center complex	358 218	.3582	.0292
1981				.0292
1982				.0292
1983	Village center complex	358 218	.3582	.0364
1984				.0364
1985				.0364
1986	Village center complex	358 218	.3582	.0435
1987				.0435
1988				.0435
1989	Village center complex	358 218	.3582	.0507
1990				.0507
1991				.0507
1992	Village center complex	358 218	.3582	.0579
1993				.0579
1994				.0579

TABLE E-93.- MIUS OPTION II TRENCHING COSTS (DCF PROGRAM OUTPUT)

FUEL COST IS 102.00 CENTS PER MBTU, WITH ESCALATION RATIO 0.050
ELECTRICITY RATE IS 0.01745 DOLLARS PER KWH
THIS RUN MADE 11/ 5/73

D. C. F. ANALYSIS FOR
MIUS UTILITY TRENCHING - OPTION 2 (8 MIUS) 8/7/73

COST FLOW TABLE
(ALL COSTS IN $ X 10E6)

YEAR	INVESTMENT COST	MAINTENANCE COST	OPERATIONS COST	TOTAL COST	PRESENT VALUE	CUMULATIVE P.V.COST
1975	1.038	0.000	0.000	1.038	1.038	1.038
1976	0.269	0.000	0.000	0.269	0.234	1.272
1977	1.212	0.000	0.000	1.212	0.917	2.188
1978	0.172	0.000	0.000	0.172	0.113	2.302
1979	0.177	0.000	0.000	0.177	0.101	2.403
1980	1.325	0.000	0.000	1.325	0.659	3.062
1981	0.188	0.000	0.000	0.188	0.081	3.143
1982	0.321	0.000	0.000	0.321	0.121	3.264
1983	1.448	0.000	0.000	1.448	0.473	3.737
1984	0.206	0.000	0.000	0.206	0.058	3.795
1985	0.212	0.000	0.000	0.212	0.052	3.848
1986	1.582	0.000	0.000	1.582	0.340	4.188
1987	0.225	0.000	0.000	0.225	0.042	4.230
1988	0.383	0.000	0.000	0.383	0.062	4.292
1989	1.729	0.000	0.000	1.729	0.244	4.536
1990	0.245	0.000	0.000	0.245	0.030	4.567
1991	0.253	0.000	0.000	0.253	0.027	4.594
1992	1.976	0.000	0.000	1.976	0.184	4.777
1993	0.358	0.000	0.000	0.358	0.029	4.806
1994	0.368	0.000	0.000	0.368	0.024	4.832

COST TOTALS FOR THE 20 YEAR PERIOD FROM 1975 TO 1994

	1973 PRICES NON-DISCOUNTED	ESCALATED PRICES NON-DISCOUNTED	ESCALATED PRICES DISCOUNTED TO 1975
CAPITAL EQUIP.	9.813	13.686	4.832
LESS RESID. VALUE	9.813	14.096	0.861
NET CAPITAL COSTS	0.000	-0.410	3.971
COSTS FOR FUEL	0.000	0.000	0.000
OTHER OP. COSTS	0.000	0.000	0.000
MAINTENANCE COSTS	0.000	0.000	0.000
TOTAL COSTS	0.000	-0.410	3.971

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TABLE E-94.- MIUS OPTION II UTILITY TRENCHING COSTS (ANNUAL CAPITAL OUTLAYS)

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1975	Village A:		
	Village center		
	Wastewater	120 295	
	Common utility	49 923	
	Neighborhoods A-1, A-2, and A-3 submains		
	Wastewater	439 968	
	Common utility	170 085	
	Neighborhoods A-1, A-2, and A-3 laterals		
	One-third of wastewater	123 452	
	One-third of common utility	74 520	0.9782×10^6
1976	Village A:		
	Neighborhoods A-1, A-2, and A-3 laterals		
	One-third of wastewater	123 452	
	One-third of common utility	74 520	
	Town center mains:		
	Wastewater	75 998	
	Common utility	21 642	.2461
1977	Village A:		
	Neighborhoods A-1, A-2, and A-3 laterals		
	One-third of wastewater	123 452	
	One-third of common utility	74 520	
	Village B:		
	Village center (same as village A center)	170 218	
	Neighborhoods B-1, B-2, and B-3 submains (same as neighborhood submains in village A)	610 053	
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	1.077
1978	Village B:		
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	.1485
1979	Village B:		
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	.1485
1980	Village B:		
	Neighborhoods B-1, B-2, and B-3 laterals		
	One-fourth of wastewater	92 589	
	One-fourth of common utility	55 890	
	Village C:		
	Village center (same as village A center)	170 218	
	Neighborhoods C-1, C-2, and C-3 submains (same as neighborhood submains in village A)	610 053	

TABLE E-94.- Continued

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals (same as neighborhood laterals in village B)	148 479	1.077x10[6]
1981	Village C:		
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals	148 479	.1485
1982	Village C:		
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals	148 479	
	Town center mains:		
	Wastewater	75 998	
	Common utility	21 642	.2461
1983	Village C:		
	One-fourth of neighborhoods C-1, C-2, and C-3 laterals	148 479	
	Village D:		
	Village center (same as village A center)	170 218	
	Neighborhoods D-1, D-2, and D-3 submains (same as neighborhood submains in village A)	610 053	
	Neighborhoods D-1, D-2, and D-3 laterals (same as neighborhood laterals in village B)	148 479	1.077
1984	Village D:		
	One-fourth of neighborhoods D-1, D-2, and D-3 laterals	148 479	.1485
1985	Village D:		
	One-fourth of neighborhoods D-1, D-2, and D-3 laterals	148 479	.1485
1986	Village D:		
	One-fourth of neighborhoods D-1, D-2, and D-3 laterals	148 479	
	Village E:		
	Village center (same as village A center)	170 218	
	Neighborhoods E-1, E-2, and E-3 submains (same as neighborhood submains in village A)	610 053	
	Neighborhoods E-1, E-2, and E-3 laterals (same as neighborhood laterals in village B)	148 479	1.077
1987	Village E:		
	One-fourth of neighborhoods E-1, E-2, and E-3 laterals	148 479	.1485

TABLE E-94.- Concluded

Year	Description	Major component capital cost, 1973 $	Total capital cost, 1973 $
1988	Village E:		
	One-fourth of neighborhoods E-1, E-2, and E-3 laterals	148 479	
	Town center mains		
	Wastewater	75 998	
	Common utility	21 642	0.2461×10^6
1989	Village E:		
	One-fourth of neighborhoods E-1, E-2, and E-3 laterals	148 479	
	Village F:		
	Village center (same as village A center)	170 218	
	Neighborhoods F-1, F-2, and F-3 submains (same as neighborhood submains in village A)	610 053	
	Neighborhoods F-1, F-2, and F-3 laterals (same as neighborhood laterals in village B)	148 479	1.077
1990	Village F:		
	One-fourth of neighborhoods F-1, F-2, and F-3 laterals	148 479	.1485
1991	Village F:		
	One-fourth of neighborhoods F-1, F-2, and F-3 laterals	148 479	.1485
1992	Village F:		
	One-fourth of neighborhoods F-1, F-2, and F-3 laterals	148 479	
	Village G:		
	Village center (same as village A center)	170 218	
	Neighborhoods G-1, G-2, and G-3 submains (same as neighborhood submains in village A)	610 053	
	Neighborhoods G-1, G-2, and G-3 laterals (same as neighborhood laterals in village A)	197 972	1.128
1993	Village G:		
	One-third of neighborhoods G-1, G-2, and G-3 laterals	197 972	.1980
1994	Village G:		
	One-third of neighborhoods G-1, G-2, and G-3 laterals	197 972	.1980

TABLE E-95.- ILLUSTRATION OF MIUS OPTION II WASTEWATER TRENCHING COSTS

[Baseline collection system]

Manhole position: From -	Manhole position: To -	Line length, ft	Pipe diameter in.	Depth, ft: Start	Depth, ft: End	Trench cost, $/ft	Total trench cost, $
Village Submains							
29	30	500	15	11.26	12.74	9.75	4 875
30	31	400	15	12.74	13.92	11.20	4 480
31	32	400	15	13.92	15.10	12.85	5 140
39	40	550	15	11.26	12.88	9.75	5 362
High school	32	1500	8	6.0	16.50	8.85	13 275
32	35	450	18	16.50	[1]17.50	17.10	7 695
35	36	450	18	17.50	[1]18.50	18.35	8 258
36	37	200	18	18.50	[1]18.97	18.65	3 730
37	40	550	24	18.97	[2]19.85	19.00	10 450
Total							63 265
Other laterals							
Elementary school	13	900	8	6	12.3	6.55	5 895
Townhouse	11	550	8	6	9.85	5.50	3 025
Townhouse	11	650	8	6	10.55	6.10	3 965
Townhouse	Main	100x6	8	6	6.7	4.40	2 640
Townhouse	12	100	8	6	6.7	4.40	440
Townhouse	14	100	8	6	6.7	4.40	440
Townhouse	12	200	8	6	7.4	4.60	920
Townhouse	14	200	8	6	7.4	4.60	920
Garden apartment	28	550	8	6	9.85	5.50	3 025
Recreation center	High rise	750	8	6	11.25	6.40	4 800
High rise	36	850	8	11.25	17.20	12.30	10 455
Commercial area	35	100	8	12	12.70	10.20	1 020
Office building	31	100	8	12	12.70	10.20	1 020
Office building	Main	100	8	12	12.70	10.20	1 020
Total							39 585

[1]Includes 5-foot shored trench at bottom.
[2]Includes 5-foot shored trench at bottom and 3-inch wide at trench bottom.

TABLE E-95.- Concluded

Manhole position		Line length, ft	Pipe diameter in.	Depth, ft		Trench cost, $/ft	Total trench cost, $
From -	To -			Start	End		
Conventional village center							
Total submains							63 265
Other laterals							39 585
Total							102 850
MIUS option II additions to submains							
36	45	400	21 1.7 ft drop	[1]18.5	20.2	20.75	18 675
45	46	500	21				
47	47	450	24 1.6 ft drop	[2]20.2	21.8	22.50	22 500
47	MIUS	550	24				
MIUS option II subtractions from other laterals							
High rise	36	850	8				10 455
High school	34	1500	8				13 275
34	32						23 730
Village center net (MIUS option II)							
Submains							104 440
Other laterals							120 295

[1]Includes 5-foot shored trench at bottom.
[2]Includes 5-foot shored trench at bottom and 3-inch wide at trench bottom.

TABLE E-96.- STEAM-ELECTRIC PLANT CAPITAL COST AND MANPOWER VARIATION

[From refs. E-25 and E-26]

Plant location	Plant size, MW	Employees per MW	Breakdown of plant capital costs, percent		
			Land and rights	Structures and improvements	Equipment
Coal:					
Captina, W. Va.	1633	0.067	0.4	10.8	88.8
Aberdeen, Ohio	1220	.098	.5	12.3	87.2
Monroe, Mich.	817	.162	1.9	21.0	77.1
St. Albans, W. Va.	816	.251	.3	12.0	87.7
Wateree, S.C.	772	.080	.4	12.3	87.3
Cayuga, Ind.	531	.149	.6	25.9	73.5
Tampa, Fla.	446	.168	5.5	19.8	74.7
Center, N. Dak.	235	.213	.8	2.4	96.8
Homer City, Pa.	1319	.124	1.7	20.1	78.2
Genoa, Wis.	346	.246	.8	15.6	83.6
Minimum		.067	.3	2.4	73.5
Maximum		.251	5.5	25.9	96.8
Average		.156	1.3	15.2	83.5
Oil:					
Sandwich, Mass.	543	.110	.4	14.1	85.5
Northport, N.Y.	774	.114	1.7	12.9	85.3
Taunton, Mass.	28	.750	1.5	27.1	71.3
Minimum		.110	.4	12.9	71.3
Maximum		.750	1.7	27.1	85.5
Average		.325	1.2	18.0	80.7

TABLE E-96.- Continued

Plant location	Plant size, MW	Employees per MW	Breakdown of plant capital costs, percent		
			Land and rights	Structures and improvements	Equipment
Gas:					
Point Comfort, Tex.	261	0.130	1.3	18.3	80.4
Lubbock, Tex.	248	.113	2.1	9.6	88.3
Baytown, Tex.	765	.101	--	--	--
Riesel, Tex.	581	.071	--	--	--
Hobbs, N. Mex.	114	.211	.2	12.3	87.5
Minimum		.071	.2	9.6	80.4
Maximum		.211	2.1	18.3	88.3
Average		.125	1.2	13.4	85.4
Oil/gas:					
Tallahassee, Fla.	105	.305	--	--	--
Kanawa, Okla.	653	.080	3.2	24.2	72.6
Willis, La.	543	.063	5.7	19.8	74.5
Yerington, Nev.	220	.141	.2	13.6	86.1
Gordon, Tex.	75	.253	.5	15.0	84.4
Minimum		.063	.2	13.6	72.6
Maximum		.305	5.7	24.2	86.1
Average		.168	2.4	18.2	79.4
Coal/gas:					
Bullhead City, Nev.	1636	.059	.3	3.8	96.0
Farmington, N. Mex.	1636	.105	.0	5.1	94.9
Billings, Mont.	173	.185	.3	9.1	90.6
Minimum		.059	.0	3.8	90.6
Maximum		.185	.3	9.1	96.0
Average		.116	.2	6.0	93.8

TABLE E-96.- Concluded

Plant location	Plant size, MW	Employees per MW	Breakdown of plant capital costs, percent		
			Land and rights	Structures and improvements	Equipment
Nuclear:					
Hartsville, S.C.	769	0.120	--	<25.6	<74
Monticello, Minn.	569	.128	0.1	23.1	76.8
Waterford, Conn.	662	--	3.5	16.2	80.3
Two Creeks, Wis.	524	--	.9	20.5	78.7
Ontario, N.Y.	517	.128	.6	17.2	82.2
Scriba, N.Y.	642	.108	--	--	--
Forked River, N.J.	550	.167	3.0	24.5	72.5
Minimum		.108	.1	16.2	72.5
Maximum		.167	3.5	24.5	82.2
Average		.130	1.6	20.3	78.1

TABLE E-97.- NEW STEAM-ELECTRIC PLANT PRODUCTION COSTS

[From refs. E-25 and E-26]

Plant location	Year in service	Plant size, MW	Plant cost, $/kW	1973 replacement cost, $/kW	Production cost, mills/kWh		Efficiency, Btu/kWh
					O&M (no fuel)	Fuel	
Coal:							
Captina, W. Va.[1]	1971	1633	131	169	0.46	3.11	9 524
Aberdeen, Ohio[1]	1971	1220	152	196	.50	3.31	9 180
Monroe, Mich.[1]	1971	817	216	278	1.38	3.53	9 600
St. Albans, W. Va.[1]	1971	816	157	202	.36	3.59	9 101
Wateree, S.C.[1]	1970	772	130	173	.62	4.36	9 301
Cayuga, Ind.[1]	1970	531	151	201	.95	2.32	9 667
Tampa, Fla.[1]	1970	446	160	213	.99	4.16	10 510
Center, N. Dak.[2]	1970	235	163	217	.80	2.06	10 720
Homer City, Pa.	1969	1319	141	195	2.98	4.01	10 190
Genoa, Wis.	1969	346	142	197	1.11	3.64	8 780
Minimum			130	169	.36	2.06	
Maximum			216	278	2.98	4.36	
Average			154	204	1.02	3.41	9 657
Oil:							
Sandwich, Mass.	1968	543	101	144	.78	4.53	9 029
Northport, N.Y.	1967	774	129	189	.63	3.53	9 612
Taunton, Mass.	1966	28	147	219	2.22	8.64	13 002
Minimum			101	144	.63	3.53	
Maximum			147	219	2.22	8.64	
Average			126	184	1.21	5.57	10 548

[1]Pulverized coal.
[2]Lignite.

TABLE E-97.- Continued

Plant location	Year in service	Plant size, MW	Plant cost, $/kW	1973 replacement cost, $/kW	Production cost, mills/kWh		Efficiency Btu/kWh
					O&M (no fuel)	Fuel	
Gas:							
Point Comfort, Tex.	1971	261	96	124	0.53	1.98	10 023
Lubbock, Tex.	1971	248	103	133	.45	2.39	10 309
Baytown, Tex.	1970	765	--	--	.46	2.01	9 773
Riesel, Tex.	1970	581	--	--	.47	2.36	9 643
Hobbs, N. Mex.	1967	114	96	140	.72	2.10	10 730
Minimum			96	124	.45	1.98	
Maximum			103	140	.72	2.39	
Average			98	132	.53	2.17	10 096
Oil/gas:							
Tallahassee, Fla.[3]	1971	105	118	152	.40	6.98	--
Kanawa, Okla.[4]	1971	653	76	98	.24	2.04	9 904
Willis, La.[4]	1970	543	104	138	.43	2.13	10 125
Yerington, Nev.[5]	1968	220	149	212	.49	4.38	10 178
Gordon, Tex.[4]	1968	75	111	158	.36	2.29	10 705
Minimum			76	98	.24	2.04	
Maximum			149	212	.49	6.98	
Average			112	152	.38	3.56	10 228

[3]Percentage oil/gas split is not available at this time.
[4]Percentage oil/gas split, Btu, is 0/100.
[5]Percentage oil/gas split, Btu, is 1/99.

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TABLE E-97.- Concluded

Plant location	Year in service	Plant size, MW	Plant cost, $/kW	1973 replacement cost, $/kW	Production cost, mills/kWh		Efficiency Btu/kWh
					O&M (no fuel)	Fuel	
Coal/gas:							
Bullhead City, Nev.[6]	1971	1636	107	138	2.22	3.87	12 122
Farmington, N. Mex.[7]	1969	1636	95	132	.92	1.49	9 822
Billings, Mont.[8]	1968	173	124	177	.47	1.99	10 630
Minimum			95	132	.47	1.49	
Maximum			124	177	2.22	3.87	
Average			109	149	1.20	2.45	10 858
Nuclear:							
Hartsville, S.C.	1971	769	101	130	.80	2.04	11 099
Monticello, Minn.	1971	569	193	248	1.20	1.66	--
Waterford, Conn.	1970	662	146	194	.91	1.87	10 660
Two Creeks, Wis.	1970	524	141	188	.40	1.58	10 452
Ontario, N.Y.	1970	517	161	214	1.62	2.14	10 730
Scriba, N.Y.	1969	642	256	355	.94	2.24	10 627
Forked River, N.J.	1969	550	167	231	.81	1.68	10 421
Minimum			101	130	.40	1.58	
Maximum			256	355	1.62	2.24	
Average			166	223	.95	1.89	10 665

[6]Percentage oil/gas split, Btu, is 67/33.
[7]Percentage oil/gas split, Btu, is 99/1.
[8]Percentage oil/gas split, Btu, is 92/8.

TABLE E-98.- HVAC SUBSYSTEM EQUIPMENT LIST FOR NEIGHBORHOOD MIUS[1]

Description	Quantity	Unit cost, 1973 $	Capital cost, 1973 $
Absorption chiller, 738-ton	1	68 000	68 000
Compression chiller, 906-ton	1	56 500	56 500
Cooling pond, 150 by 100 by 4 ft	1	33 600	33 600
Hot-water boiler, 125-hp	2	12 340	24 680
Chilled-water pump, 3000-gal/min, 250 ft hd	4	5 455	21 820
Hot-water pumps, 1670-gal/min, 90 ft hd	3	4 422	13 266
Insulated pipe:			
12 in.	2200 ft	64.30	141 460
10 in.	2840 ft	45.46	129 106
8 in.	2860 ft	28.17	80 566
6 in.	1840 ft	18.36	33 782
5 in.	2480 ft	15.01	37 224
4 in.	1600 ft	10.86	17 376
3-1/2 in.	200 ft	9.40	1 880
3 in.	1560 ft	8.14	12 706
2 in.	2640 ft	5.77	15 232
1-1/2 in.	2000 ft	5.02	10 040
1-1/4 in.	1800 ft	4.65	8 370
Gate valves, 3 in.	136	78.35	10 655
Total			716 263
(Piping and valves only)			(498 397)

[1]High-density area only.

TABLE E-99.- ADDITIONAL CHILLED- AND HOT-WATER PIPING REQUIRED FOR THE SINGLE-FAMILY DWELLING AREA (713 UNITS) OF ONE NEIGHBORHOOD[1]

Description	Quantity, ft	Unit cost, 1973 $	Capital cost, 1973 $
Insulated pipe			
6 in.	12 000	18.05	216 558
5 in.	12 000	14.70	176 358
4 in.	3 600	10.86	39 096
3-1/2 in.	5 100	9.25	47 175
3 in.	7 200	8.14	58 608
2-1/2 in.	48 900	6.59	322 401
2 in.	43 600	5.68	247 810
1-1/2 in.	4 500	5.02	22 590
1-1/4 in.	4 500	4.65	20 925
1 in.	2 000	4.09	8 180
3/4 in.	2 000	3.46	6 920
1/2 in.	71 500	3.13	223 608
3/8 in.	71 500	2.82	201 443
Total additional piping cost for one neighborhood			1 591 672
Total additional piping cost for 21 neighborhoods			33 425 112

[1]No potable hot water. No thermal distribution losses considered in sizing the pipe. No refrigeration machines, water pumps, heat exchangers, trenching costs, elbows, flanges, reducers, or other fittings. No waste heat source is available to supply this system from the designed powerplants, solid-waste incinerators, or boiler facilities.

TABLE E-100.- INDIVIDUAL DWELLING UNIT HVAC COST FOR ONE NEIGHBORHOOD (713 UNITS)

Description	Unit cost, 1973 $	Unit maintenance cost/yr, 1973 $	Total capital, 1973 $
Case I:			
Three-ton heat pump system with 10-kW supplementary resistance heating (no ductwork)	1 540	154	1 098 000
Case II:			
Three-ton, 4-pipe, 2-valve heat exchanger with blower and filter box (no ductwork)	240	8.40	171 000
Central station refrigeration and heating equipment (ratio of that required for the high-density area)		15 740	284 000
Distribution piping			1 592 000
Total for case II			2 047 000

TABLE E-101.- INDIVIDUAL DWELLING UNIT HVAC COSTS

[Comparison of option I data with central chilled- and hot-water for the single-family dwelling units only.]

Cost factor	Option I (as presented)[1]	Chilled water (analysis Sept. 12, 1973)[2]
Total capital outlay, 1975-94, 1973 $	23 030 000	43 000 000
Total O&M cost, 1975-94, (no energy), 1973 $ . . .	24 192 000	3 465 000
Total outlay, 1975-94, 1973 $	47 222 000	46 465 000
Escalated and discounted[3] outlay, 1975-94, 1975 $	17 048 000	20 396 000

[1]Community growth pattern not the same because 1/20 of the 1994 total was assumed to have been installed each year.

[2]Refrigeration machines and associated equipment taken in direct proportion to that determined for the high-density area of option I.

[3]All items escalated at 3 percent/yr, discounted at 15 percent/yr.

TABLE E-102.- VACUUM SEWER SYSTEM COSTS FOR MIUS

Description	Cost, $	
	Vacuum toilets	Conventional toilets
Collection stations:		
Town center	52 000	58 000
Hospital	35 900	38 000
Plumbing	198 000	198 000
Village center, 7 ea.	267 400	298 200
Plumbing for 7 stations	154 000	154 000
Neighborhood, 7 ea. (townhouses and single-family dwellings)	1 155 000	1 293'600
Plumbing for 7 stations	9 355 500	9 355 500
Subtotal	11 217 800	11 395 300
Forced mains:		
Town center Hospital	223 665	447 300
Village center Neighborhood (townhouses and single-family dwellings)	3 613 050	5 014 800
Total	15 054 515	16 857 400

[1]Personal communication, Colt Industries, Beloit, Wis., 1973.

Name of Utility PENNSYLVANIA ELECTRIC COMPANY

Line No.		
	Name of Plant	Homer City 1/ 2/
	Region and Power Supply Area	I-5
	Location of Plant	Homer City, Pa.

Line No.			
1	Installed Generating Capacity - Max. Gen. Nameplate Rating - Megawatts	1,319.4	
2	Net Generation, Million Kilowatt-hours	703.6 3/	
3	Plant Factor, Percent, Based on Nameplate Rating (Line 1)	—	
4	Peak Demand on Plant, Megawatts (60 Minutes) (Net)	612.0	
5	Net Continuous Plant Capability, Megawatts		
6	When not Limited by Condenser Water	1,025.0	
7	When Limited by Condenser Water	1,025.0	
8	COST OF PLANT (Thousands of Dollars)		
9	Land and Land Rights	3,167	
10	Structures and Improvements	35,225	
11	Equipment	136,775	
12	Total Cost	175,167	
13	Cost per Kilowatt of Installed Capacity (Line 12/Line 1) $	133	
14	PRODUCTION EXPENSES	$1000	Mills Kwh
15	Operation Supervision and Engineering	56	.08
16	Steam Expenses	220	.31
17	Steam from Other Sources		
18	Steam Transferred (Cr.)		
19	Electric Expenses	42	.06
20	Misc. Steam Power Expenses	80	.11
21	Rents	6	.01
22			
23	Maintenance Supervision and Engineering	23	.03
24	Maintenance of Structures	6	.01
25	Maintenance of Boiler Plant	258	.37
26	Maintenance of Electric Plant	21	.03
27	Maintenance of Misc. Steam Plant	20	.03
28			
29	Total, Exclusive of Fuel	732	1.04
30	Fuel	1,729	2.46
31	Total Production Expenses	2,461	3.50
32	FUEL USED	Quantity	Cost
33	Coal burned, 1000 tons of 2000 lbs. and Cost per ton $	322.6	5.36
34	Btu per Pound and Cost per Million Btu ¢	11,392	23.53
35	Cost per Ton, as delivered, f.o.b. Plant during reported year $		5.25
36	Oil burned, 1000 bbls. of 42 gals. and Cost per bbl. $		
37	Btu per Gallon and Cost per Million Btu ¢		
38	Cost per Barrel, as delivered, f.o.b. Plant during reported year $		
39	Gas burned, Million cu. ft., and Cost per 1000 cu. ft. ¢		
40	Btu per Cubic Foot and Cost per Million Btu ¢		
41			
42			
43			
44	Average Btu per Kilowatt-hour Net Generation	10,449	
45	Total Number of Units (Exclusive of House Service Units)	2	
46	Number of Reheat Units	2	
47	Reheat Units — Total Megawatts	1,319.4	
48	Condensing Water Supply	4/	
49	Average Number of Employees	105	
50	Plant Building - Type of Construction (Conv., Semi-O.D., O.D.)	Conv.	
51	Initial Year of Plant Operation	1969	

ADDITIONS, RETIREMENTS AND CHANGES IN 1969

		GENERATORS				TURBINES					BOILERS						
	No. of T.G. Units	Max. Cont. Rating MW	Coolant Pressure (Hydrogen or Other)	P F %	Voltage K V	Max. Cont. Rating MW	Throttle PSI	Throttle Temp. °F Initial	Throttle Temp. °F Reheat	R P M	No.	1000 lbs. per hr. Max. Cont. Rating	P S I	Temp °F Initial	Temp °F Reheat	Fuel & Methods of Firing (Pulv. Coal, Cyclone Furnace, Stoker, Gas, Oil)	Year
2/	2	659.7	60	90	20.0	659.7	3,500	1,000	1,000	3,600	2	4,620.0	3,800	1,005	1,005	Pulv. Coal	1969

1/ Jointly-owned with New York State Electric & Gas Corp., each Company having a 50% undivided interest in the two unit plant. Pennsylvania Electric Co. operates the plant.

2/ New Plant - Commercial Operation Unit No. 1, July 31, 1969. Unit No. 2, Dec. 11, 1969.

3/ Excludes test generation of 134.2 million kwh.

4/ Reservoir and Natural Draft Cooling Towers.

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Figure E-1.- Example of summary cost data for conventional electrical power, Homer City, Pa., powerplant (ref. E-25).

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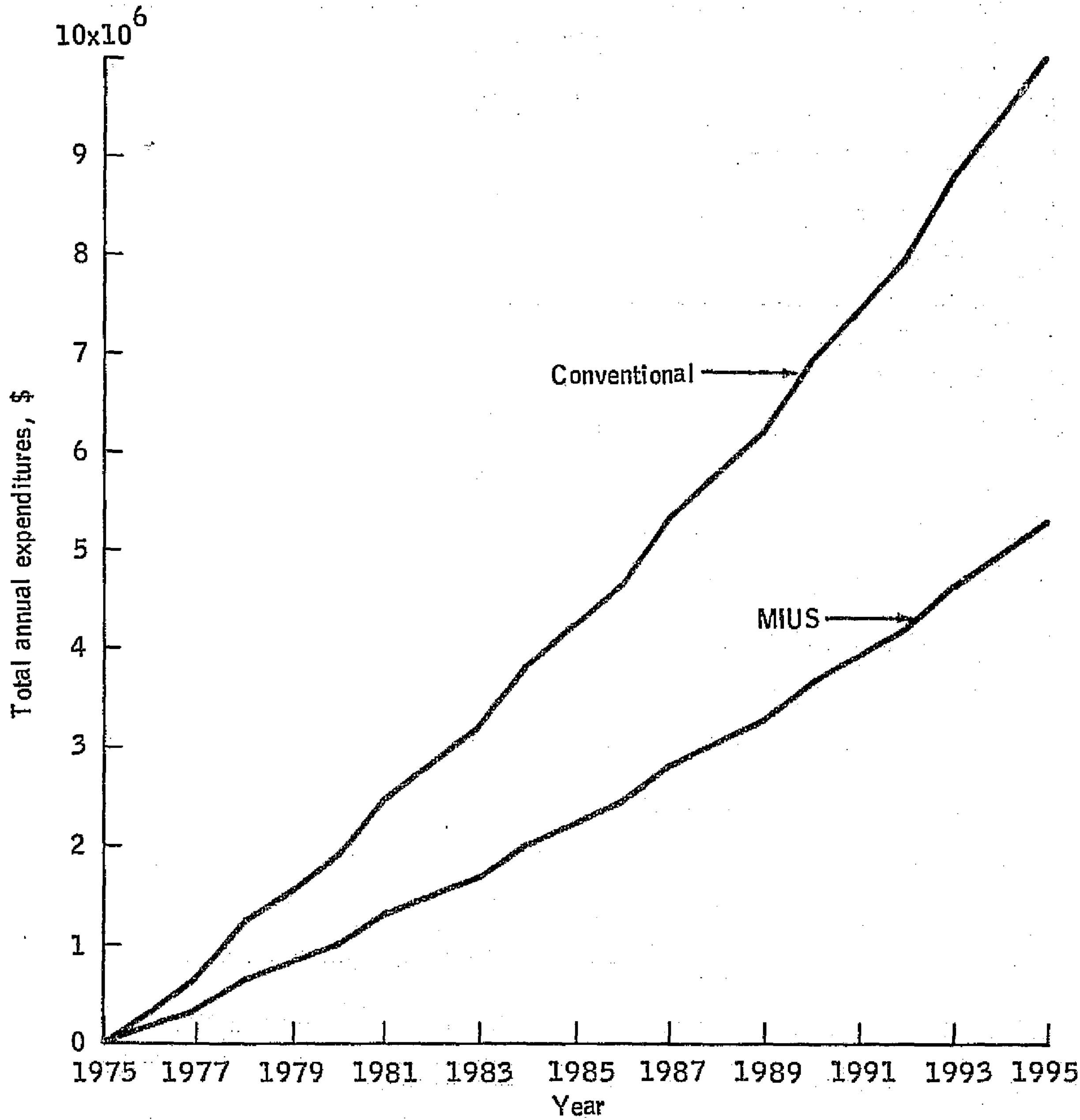
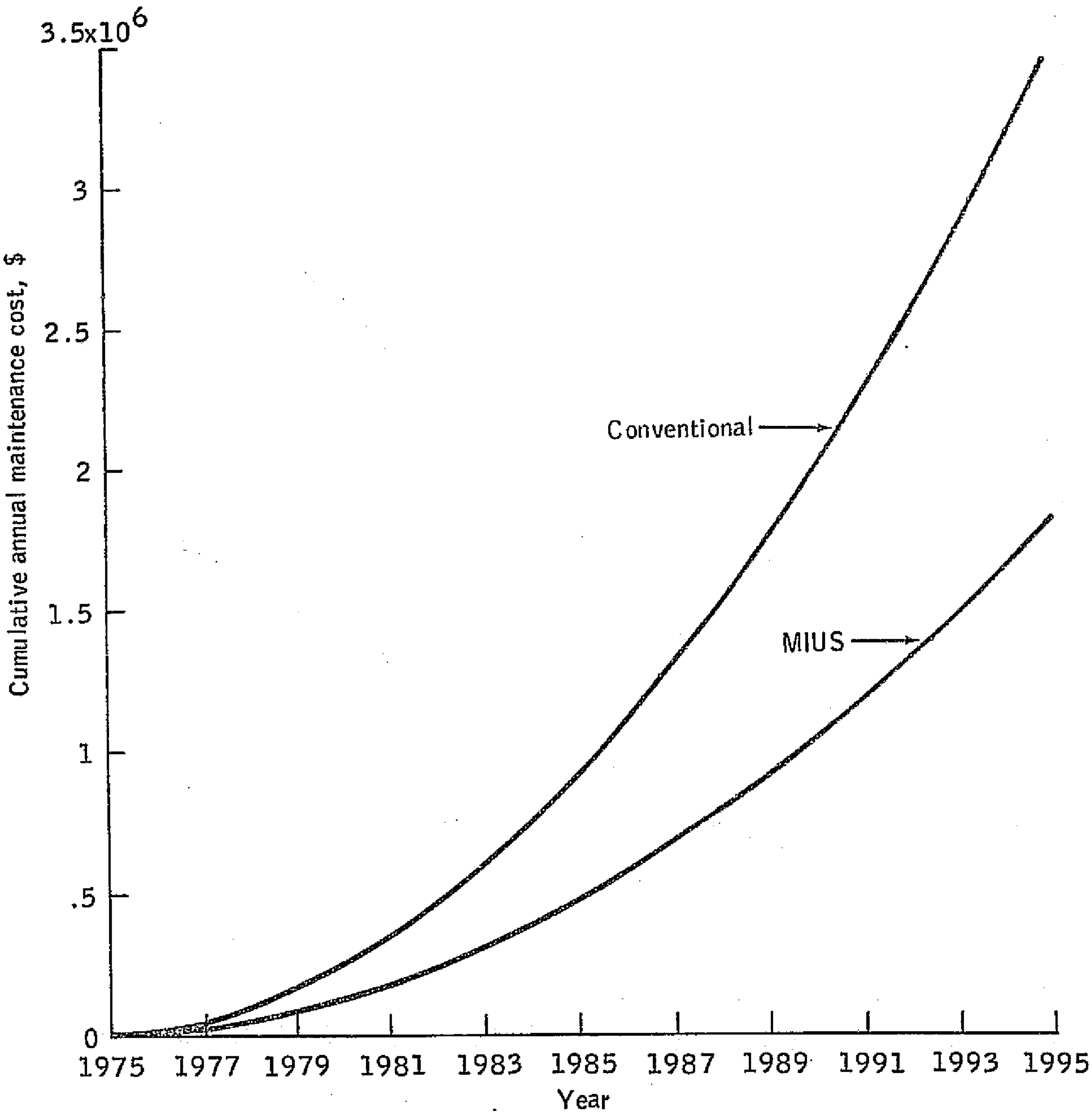


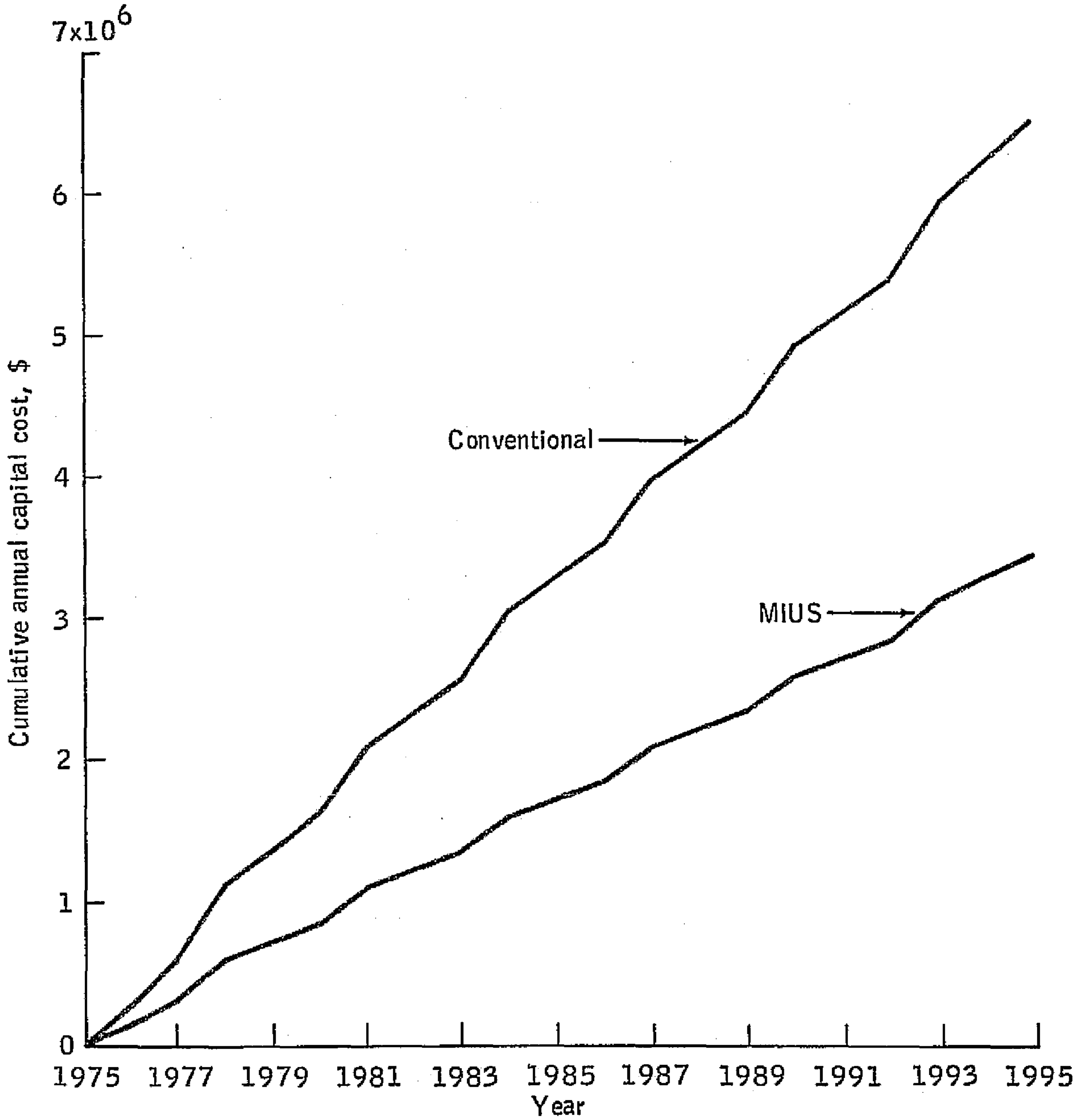
(a) Total expenditures.

Figure E-2.- Cost comparison of the HVAC system. (Sample program outputs.)



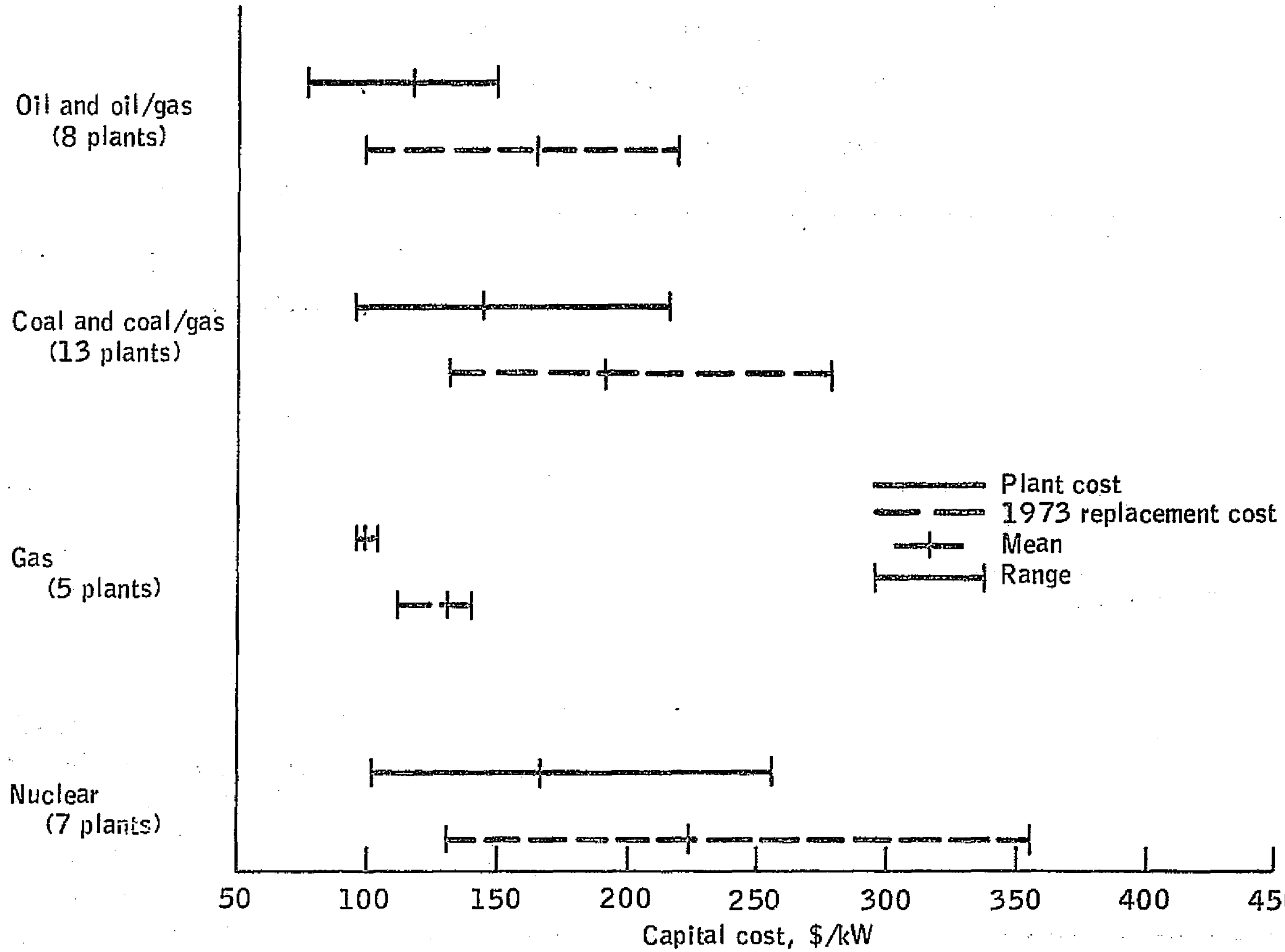
(b) Maintenance expenditures.

Figure E-2.- Continued.



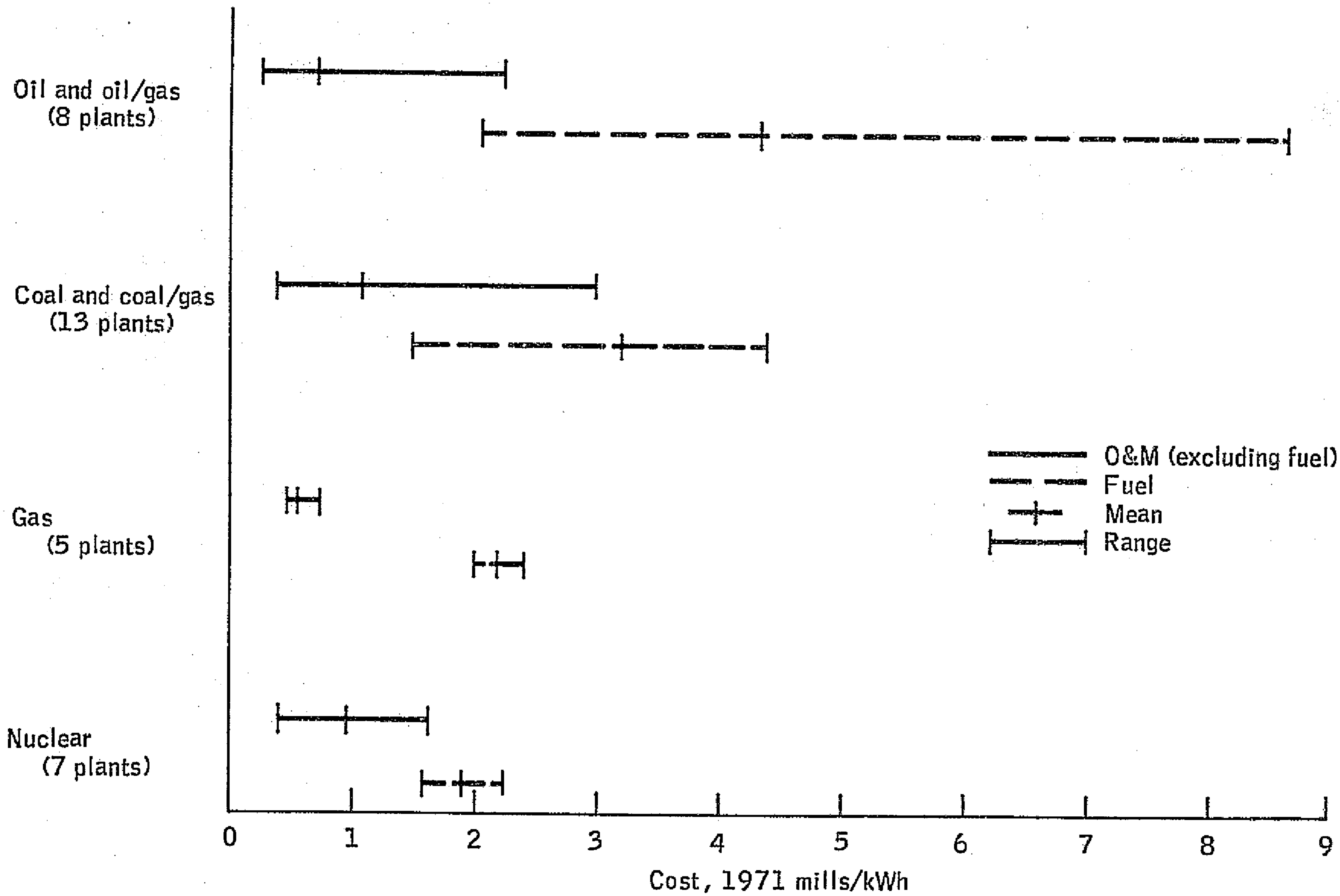
(c) Capital costs.

Figure E-2.- Concluded.



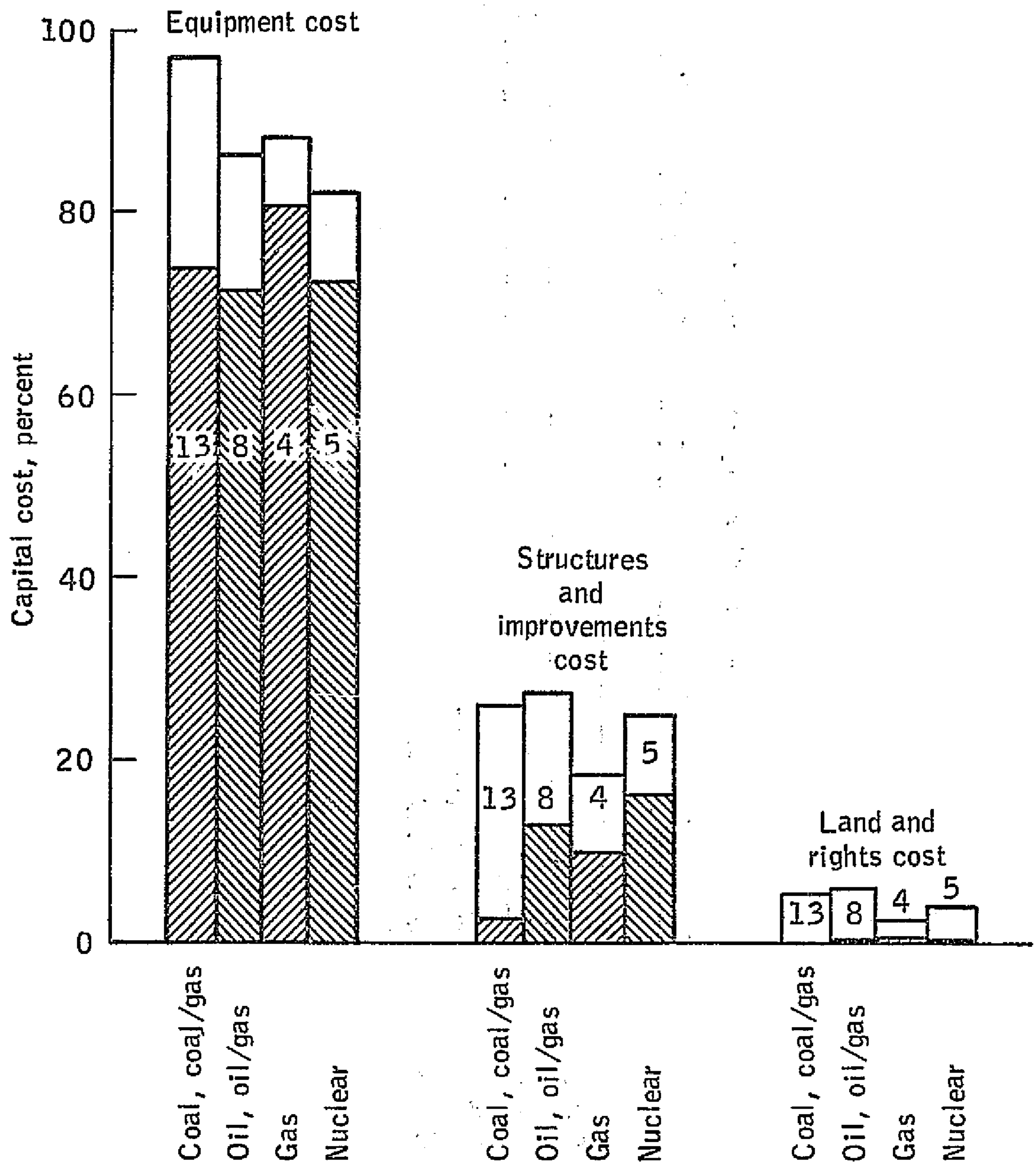
(a) Capital costs.

Figure E-3.- Steam-electric powerplant costs.



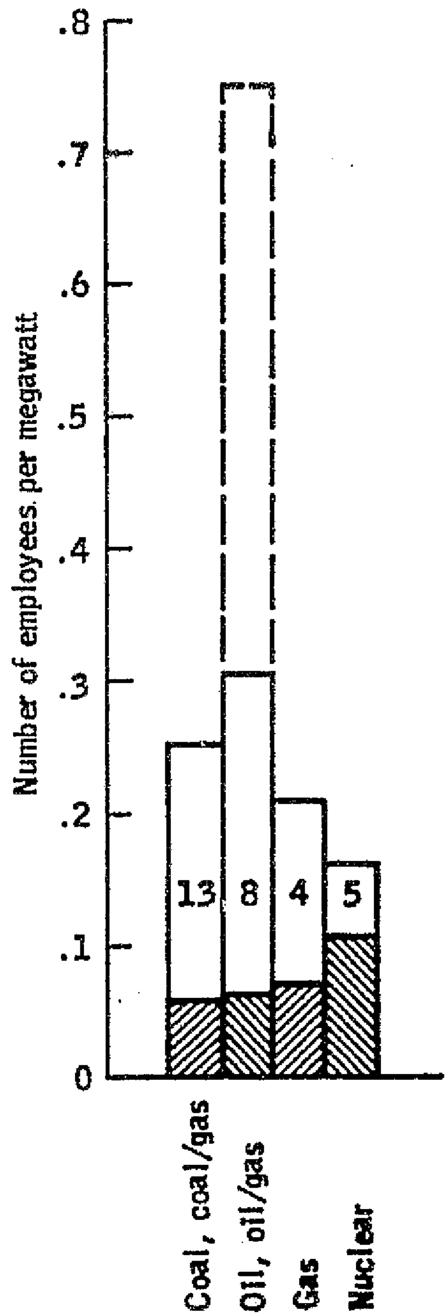
(b) Production costs (1971 costs).

Figure E-3.- Concluded.



(a) Capital cost.

Figure E-4.- Conventional electrical powerplant data (from table E-96). Numbers indicate the number of plants of a given type, shaded areas extend to minimum values, top of bars indicate maximum values, and dashed area represents extrapolation based on more realistic plant size. (The manpower data are from a 28-MW plant.)



(b) Manpower.

Figure E-4.- Concluded.